MECHANICAL ENGINEERING

October 1959

Management's Changing Responsibilities, 42

Transporting Materials in Bulk, 54

Bearings, Lubricants and Lubrication—
A Digest of 1958 literature, 56

Beam Column Behavior of Brittle Members, 45

Materials for Service Above 1000 F, 46
METALS AND CERAMICS · PLASTICS

Hot-Gas Motor, 70

Shock Tube for Re-entry Study

Science for the world's well-being

Pfizer

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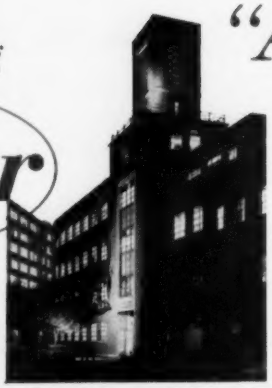

"A very satisfactory and dependable Boiler"

says C. V. Reichelt, Director of Engineering, Chas. Pfizer & Co., Inc.

Pfizer headquarters: executive offices and research laboratories in Brooklyn, New York. In the associated production plant, a modern Combustion VU-50 Boiler has been meeting essential heat and processing requirements during the past four years by producing 140,000 lbs of steam per hour.

Pfizer's Vigo Plant relies on four Combustion VM Boilers fired by C-E Spreader Stokers for economical heating and processing. Well suited to fill local needs, these units are each rated at 30,000 lbs of steam per hour at an operating pressure of 150 psi. In various Pfizer plants, nine C-E units have a total steam production capability of 740,000 lbs of steam per hour.

At this large Pfizer fermentation and organic synthesis plant in Groton, Conn., a new C-E Vertical-Unit Boiler, Type VU-50X, has just been placed on the line. Rated at 165,000 lbs of steam per hour — a new high for Pfizer — it joins three other oil fired C-E boilers, two VU-40 units and one VU-50 unit, already in service at the plant. Each is rated at 115,000 lbs/hr.

When Chas. Pfizer & Co., Inc., recently put into service a new C-E Vertical-Unit Boiler in their Groton, Conn., fermentation and organic synthesis plant, they were capitalizing on long experience. Eight previous C-E units, three of them at Groton, had been producing steam efficiently in Pfizer plants since 1948.

Mr. C. V. Reichelt, Director of Engineering, describes Pfizer's experience with its latest C-E unit as follows: *"The new 165,000 lb/hr boiler . . . is proving to be a very satisfactory and dependable unit. Particular commendation is made of the refinements with regard to air pre-heater and fly ash arrestors which Combustion Engineering included in their design. Special mention is also made of the fine job that was done in getting the boiler on the line on time in spite of a tight schedule for fabrication and erection. This boiler is the fourth and largest C-E boiler installed at our Groton facilities."*

With three other C-E Boilers at Groton, this unit is now producing steam for power and process in the production of the well-known Pfizer antibiotics such as Terramycin as well as for a wide range of pharmaceuticals and chemical and agricultural products.

Pfizer's experience with C-E boilers extends beyond Groton, too. At Terre Haute, Indiana, the company's Vigo Plant uses four Combustion boilers fired by C-E Spreader Stokers; and at the Brooklyn Plant, the company's original "shop", dating back to 1849, another C-E Boiler is entering its fourth year of service.

Today, in more than 100 countries around the world, Pfizer "Science for the world's well-being" contributes to the advance of medicine, agriculture and industry. Combustion Engineering is proud to have a share in this march of scientific progress.

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MECHANICAL ENGINEERING

PUBLISHED BY
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MECHANICAL ENGINEERS

Contents

VOLUME 81 • NUMBER 10 • OCTOBER, 1959

THE COVER

Note to space voyagers—and heat-transfer engineers. Scientists at Lockheed Missiles and Space Division, Van Nuys, Calif., built this 40-ft-long shock tube to study re-entry into an atmosphere. At one end, a "vehicle"; at the other, explosive gases. In the middle, gases to simulate atmosphere. The shock wave delivered to the model generates heat as in a free flight of 20,000 mph. When gases believed to surround Venus hit the model, the heat problem proved to be 50 per cent greater than for earth re-entry.

MANAGEMENT'S CHANGING RESPONSIBILITIES.............H. K. Nason 42

A genuine "science of management" is a long way off. Meanwhile, here we are, in a world changing so fast only the well-informed, flexible, forward-looking mind can be trusted to call the plays.

BEAM COLUMN BEHAVIOR OF BRITTLE MEMBERS..........William Zuk 45

They call it the "mechanical pencil" phenomenon, and with reason. Now science has equations to predict failure with some accuracy, but not much. The dime store carries new leads on counter 8.

MATERIALS FOR SERVICE ABOVE 1000 F 46

Metals and Ceramics..................................J. J. Harwood

Plastics..Irving Gruntfest

It's not just high temperature, though combustion temperatures in rockets exceed 5000 F. There's oxidation, erosion, thermal shock. Materials? Right now, they are the limiting factor in design.

TRANSPORTING MATERIALS IN BULK...................H. A. Stoess, Jr. 54

Those two ribbons of rail: Do you know what bulk transportation by railroad car offers in economical conveyance of dry materials? Dry-Flo cars, pneumatic unloading... the boxcar has grown up.

BEARINGS, LUBRICANTS AND LUBRICATION—
A DIGEST OF 1958 LITERATURE.. 56

Would you think there'd be a completely new category in bearings? It's the gas-lubricated bearing. Here are listed 277 papers, the year's technical reports on research in bearings and lubrication.

HOT-GAS MOTOR.......................................William Patterson 70

It'll serve in planes—and elsewhere—but Vickers designed it for the big rockets: Auxiliary power, 1 to 50 hp, for limited periods. A new competitor in the field of auxiliary and starting motors.

THE UNITED ENGINEERING CENTER..................................... 73

Your new building, the United Engineering Center, is to symbolize the dignity and strength of your profession. The project calls on all engineers to demonstrate their professional solidarity.

Contents continued on following page

MECHANICAL ENGINEERING

PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Contents (continued)

VOLUME 81 • NUMBER 10 • OCTOBER, 1959

Departments

EDITORIAL 41

BRIEFING THE RECORD 75
- Inflatable Metal Tubing 75
- Vapor-Compression Water Still 76
- Automatic Monitoring of Railroads 76
- Future Power Market 76
- Automated Quality Control 78
- Gas-Turbine Blast-Furnace Blower 78
- Self-Leveling Buildings 78
- Nuclear Briefs 79
- New Boiling-Water Nuclear Plant 80
- 80 Smaller Reactor-Containment Shells
- 80 Modularizing the Steam Turbine
- 82 Electrospark Machining
- 82 Rail-Air Facilities
- 83 Industrial Jet Power
- 83 Living in Outer Space
- 84 Reliability Engineering
- 84 Roller-Bearing Expansion Adjustment
- 85 Semiautomatic Gun Drill
- 85 Insulating Refractories

PHOTO BRIEFS 86
- Big Chip 86
- Hydrofoil Landing Craft 86
- Mobile Missile 86
- Controllable-Pitch Propeller 86
- 86 Giant Positioner
- 86 Wing Attachment
- 86 Flame-Cutting Table
- 87 Mass-Produced Transistors

EUROPEAN SURVEY 88
- New Works and Research Center for Utility 88
- 88 Automatic Molding Machine
- 89 Diesel Electrics for U. K. Railways

ASME TECHNICAL DIGEST 90
- Machine Design 90
- Petroleum Mechanical Engineering 92
- Heat Transfer 94
- 98 Applied Mechanics
- 103 ASME Transactions for September, 1959

COMMENTS ON PAPERS 104

REVIEWS OF BOOKS 106

BOOKS RECEIVED IN LIBRARY 107

THE ROUNDUP 110
- Technical Institute Enrollment 110
- Cryogenic Engineering Conference 110
- NAS-NRC Committee on Materials R&D 111
- People 111
- Coming Meetings 112
- 112 Industrial Films
- 113 How R&D Fits Into Nation's Budget
- 114 UEC
- 114 Meetings of Other Societies
- 114 Education

THE ASME NEWS 115
- 1959 Annual Meeting Program 115
- ASME Technical Development Committee Report 124
- ASME Acts to Shorten Time-Lag in Applying Scientific Discoveries 126
- National Automatic Control Conference 126
- ASME Standards Workshop 127
- ASME Heat Transfer Conference 128
- 130 Durand Centennial Conference
- 131 ASME Coming Events
- 131 ASME Student Members Regional Conference
- 134 Junior Forum
- 135 1960 Mechanical Catalog
- 135 Personnel Service
- 137 Candidates
- 138 Obituaries

KEEP INFORMED 141

216 .... CONSULTANTS

CLASSIFIED ADS 207

218 .... ADVERTISING INDEX

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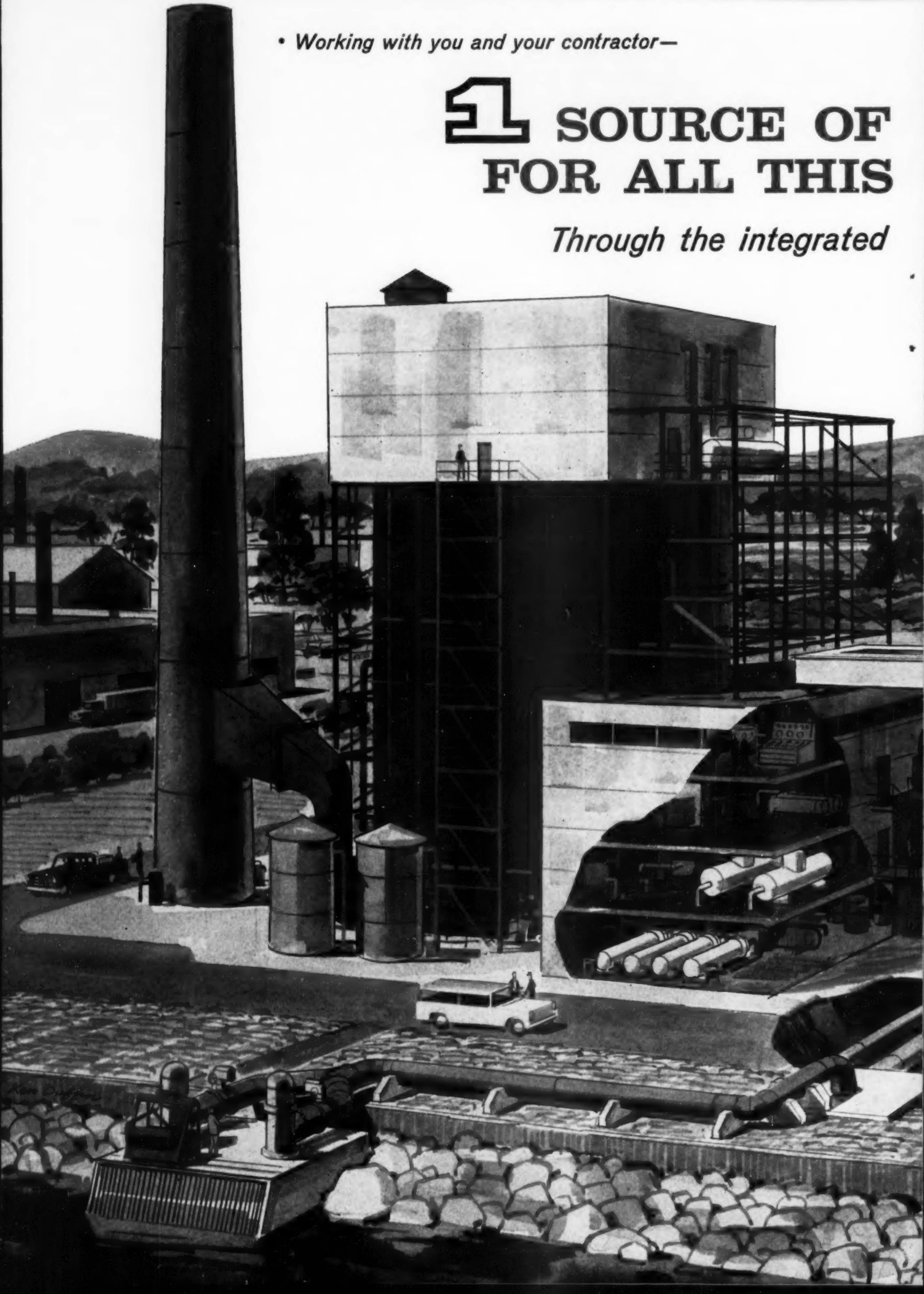

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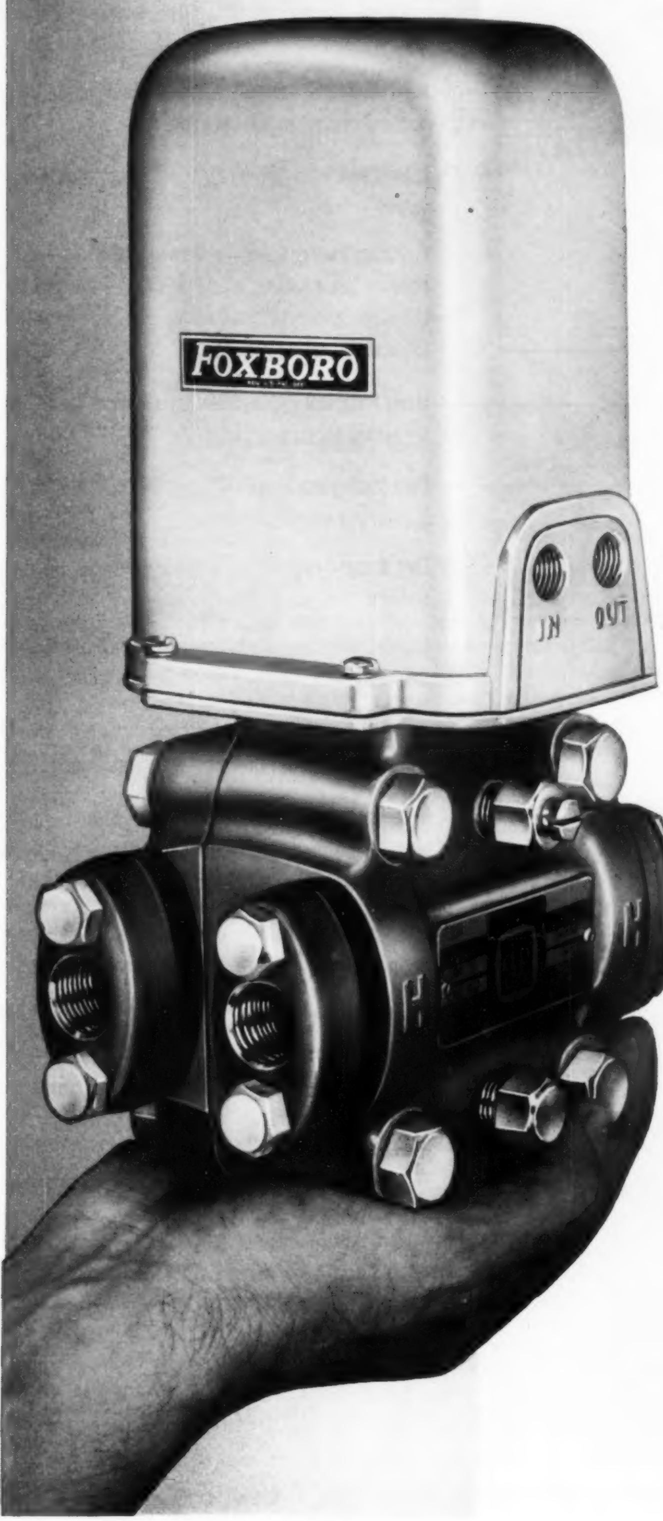

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Management is actively looking for engineers who have the desire and ability to become administrators

by James M. Jenks

In a sense, this is the golden age for engineers. Once buried in corporate obscurity, many of them have emerged today as likely heirs apparent to the big jobs—and the big rewards—of business and industry. One impressive indication of this growth is that money spent in research and development over the past fifteen years has increased six-fold.

Despite this stepped-up activity, however, the once disorganized scramble for engineers seems to have ended . . . at least temporarily. And perhaps it's a good thing. Actually, the more perceptive engineers had always realized that unusually high starting salaries were often illusory. The gap between money being offered beginners and the incomes of experienced men was narrowing rapidly. Further, more and more thinking technical men concluded that even top engineering salaries are low when compared with the remuneration of highly placed general executives.

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Happily, there is a route to increased incomes that is satisfying to both engineer and company alike. This route leads into *management*. It is no easy road but the rewards are great for those willing and able to follow it.

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Actually, it comes down to this: To succeed as a business executive, the engineer must learn the art of making decisions quickly and accurately. And this ability is, of course, directly dependent upon knowledge. The "principles" of business—while not as scientific and inexorable as those of engineering—are no less important . . . no less essential to efficient procedure.

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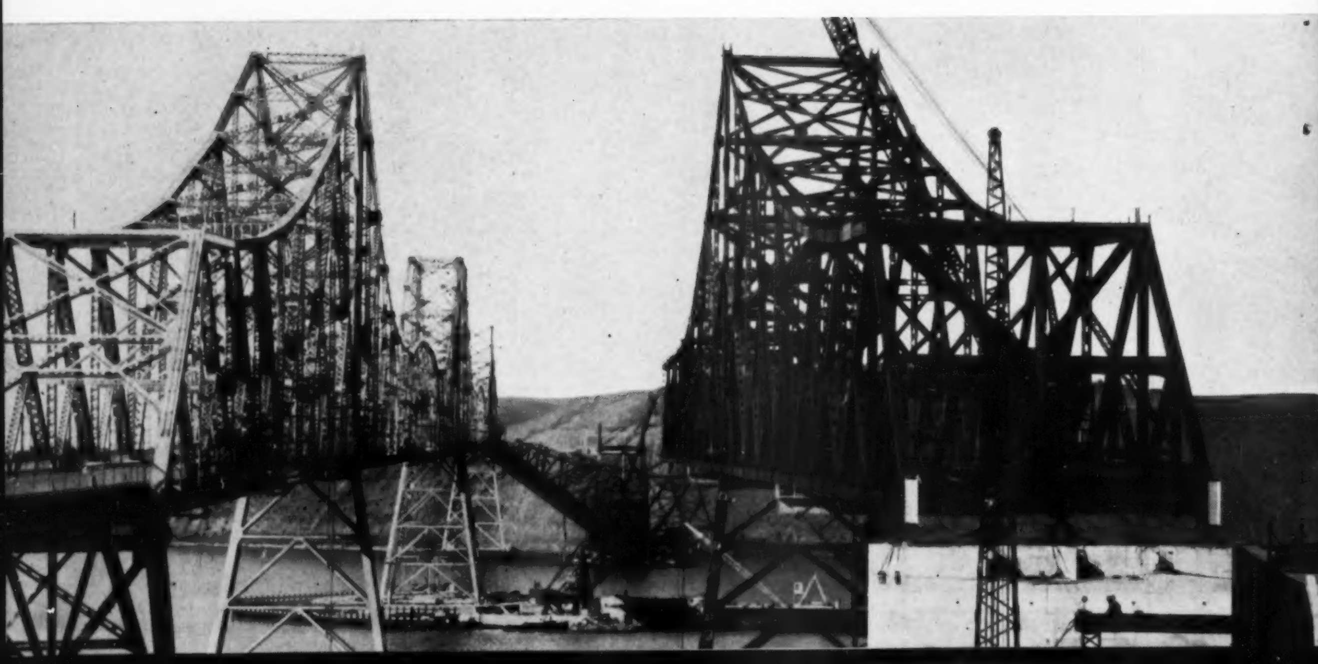

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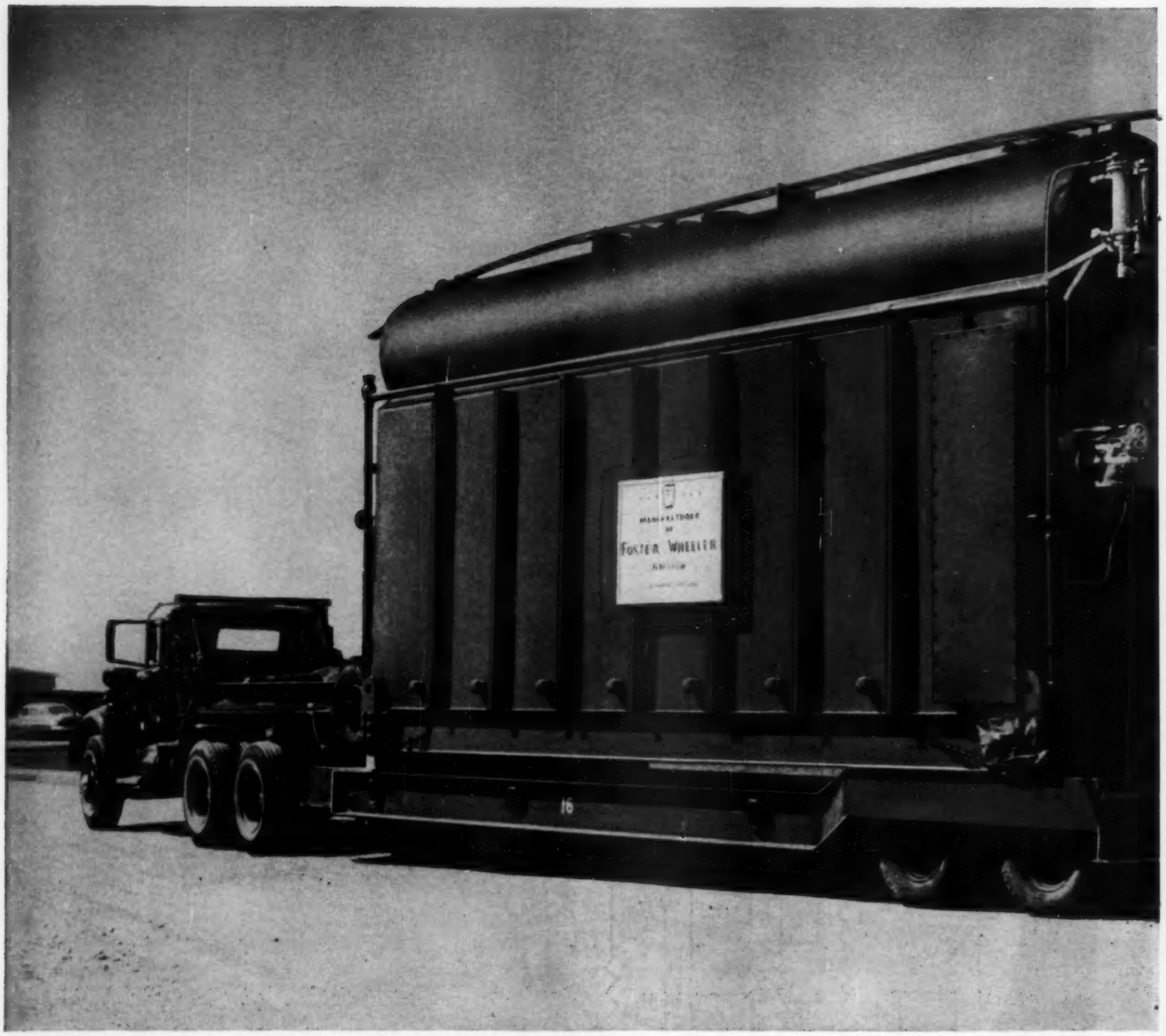

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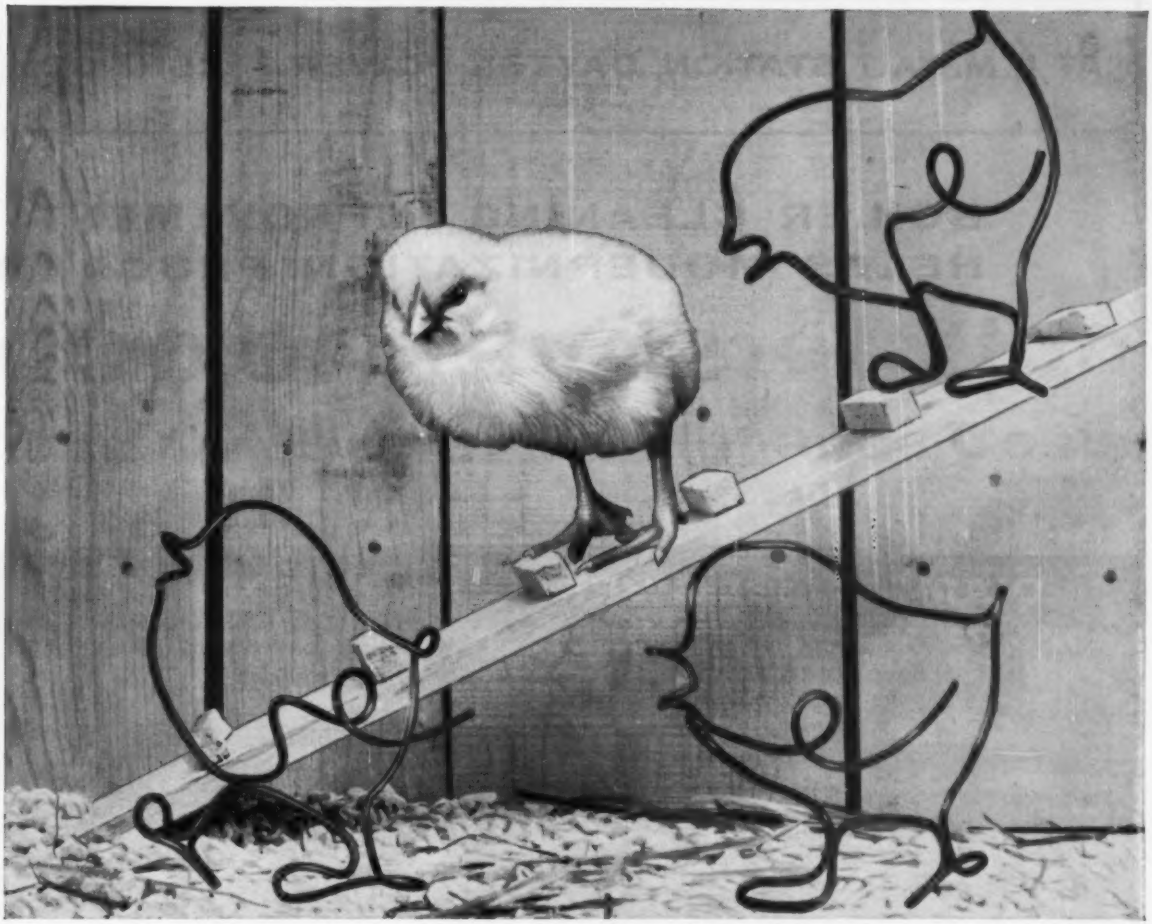

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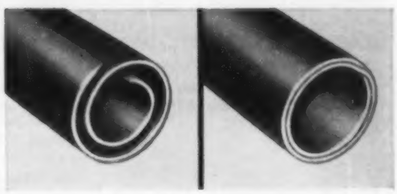

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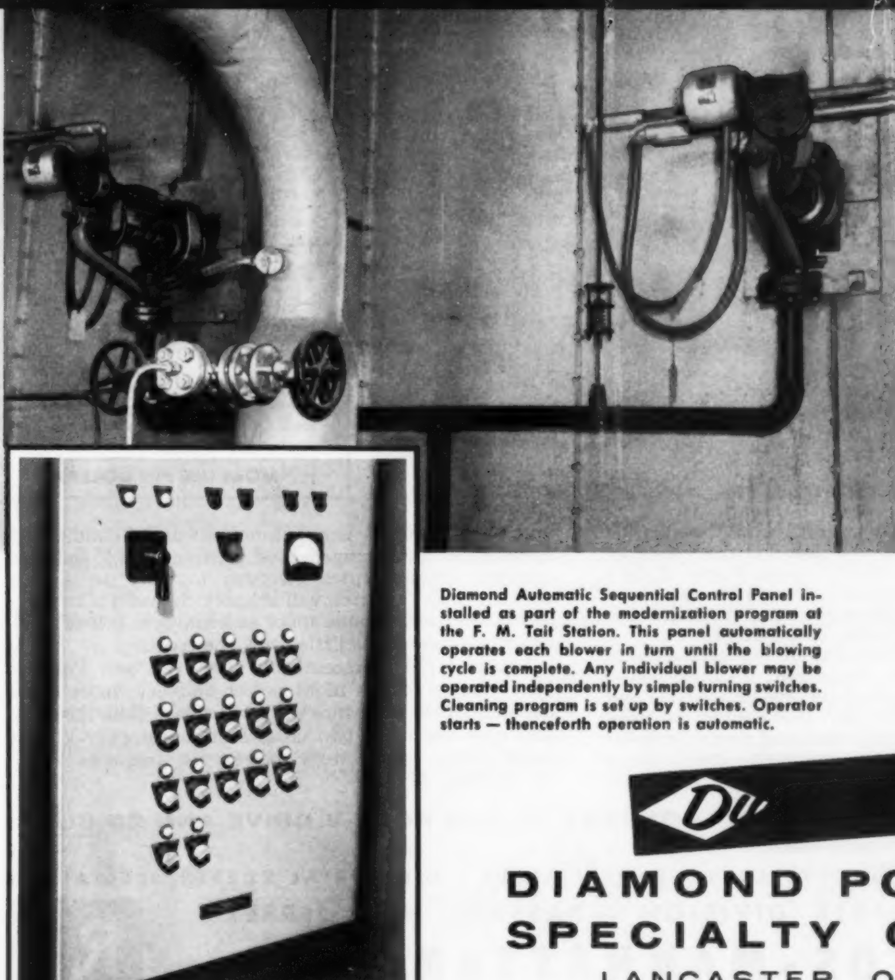

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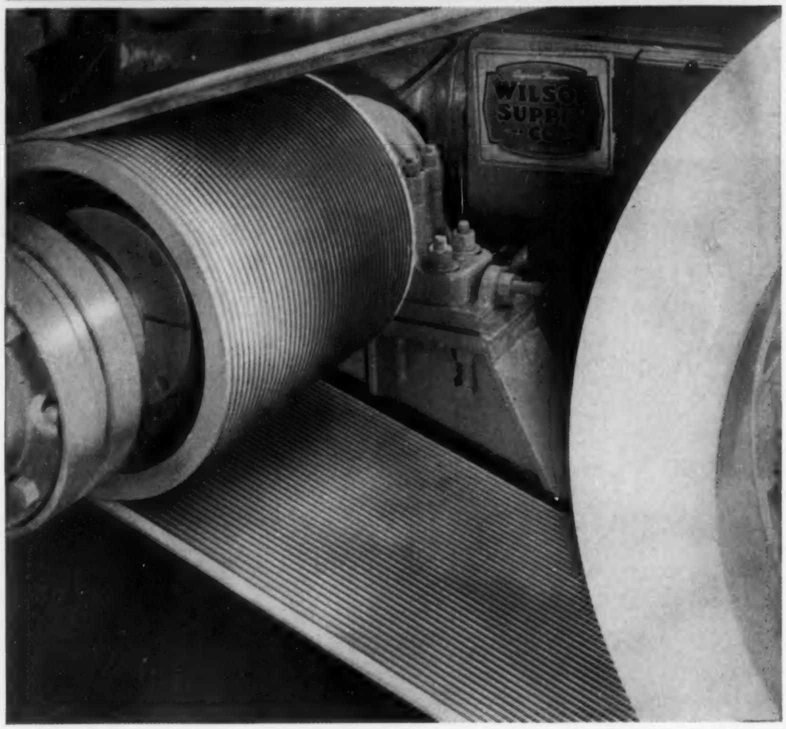

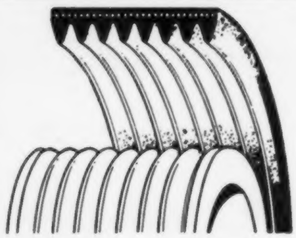

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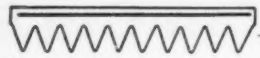

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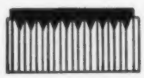

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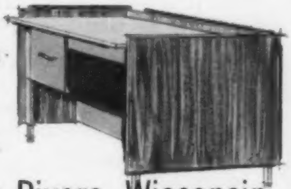

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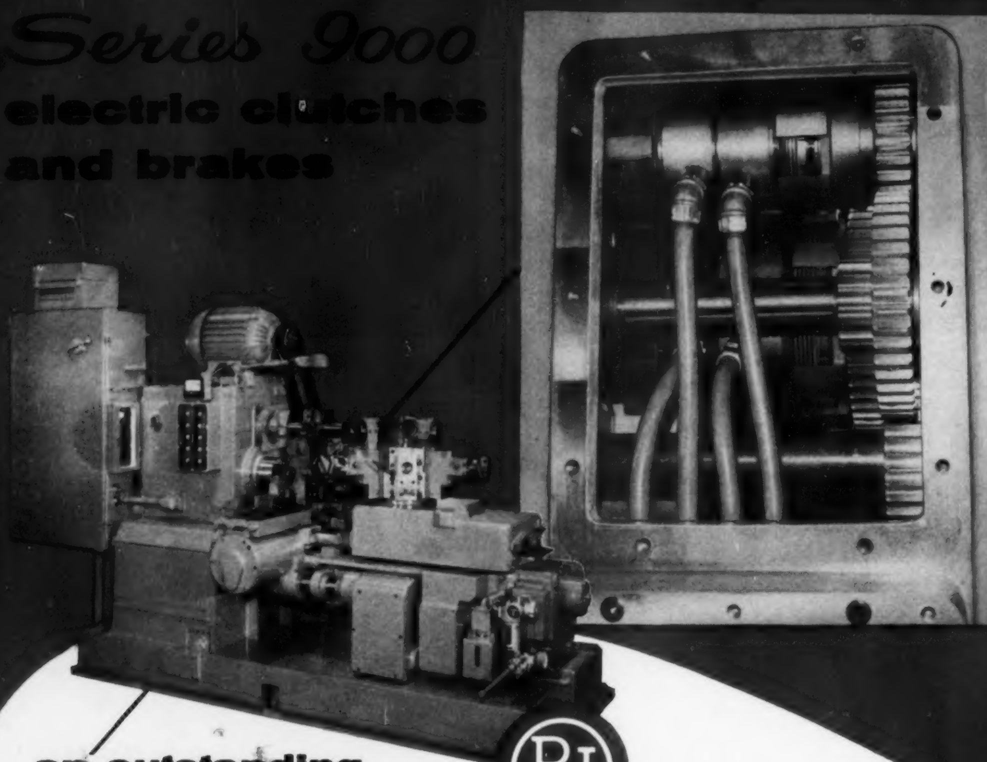

an outstanding design feature of P&J tape-controlled automatic turret lathes

Five Maxitorq Series 9000 Electric Clutches are used in the all-new Potter & Johnston No. 3E-15 Tape-Controlled Automatic Turret Lathe. Four are used in the headstock to provide automatic spindle speed changes and a fifth is used as a master clutch in the feed drive. These clutches of advanced design have PROVED their ability to assure consistent, positive and extremely fast action; essential to these machines. They transmit full load, are self-compensating for wear and permit great flexibility in control.

With operation induced entirely by magnetic flux, Maxitorq Series 9000 Electric Clutches are well adapted to a wide range of machine tool drives. They are simple and rugged in design, require no adjustments, can be used *either as a clutch or brake* and are built to American Machine Tool Standards. Disc separators not only separate discs, providing a drag-free neutral without heating, but also break up residual magnetism and permit extremely fast, positive action.

The 9000 Series Clutches have a minimum of moving parts and the electrical operating unit remains stationary, hence, there are no brushes, slip rings or complex wiring. Maxitorq Clutches operate on 110 V. A. C. rectified to 90 V. D. C. Other voltages on special order.

If you have a clutch or brake application where you are looking for new and improved performance, bring your problem to us.

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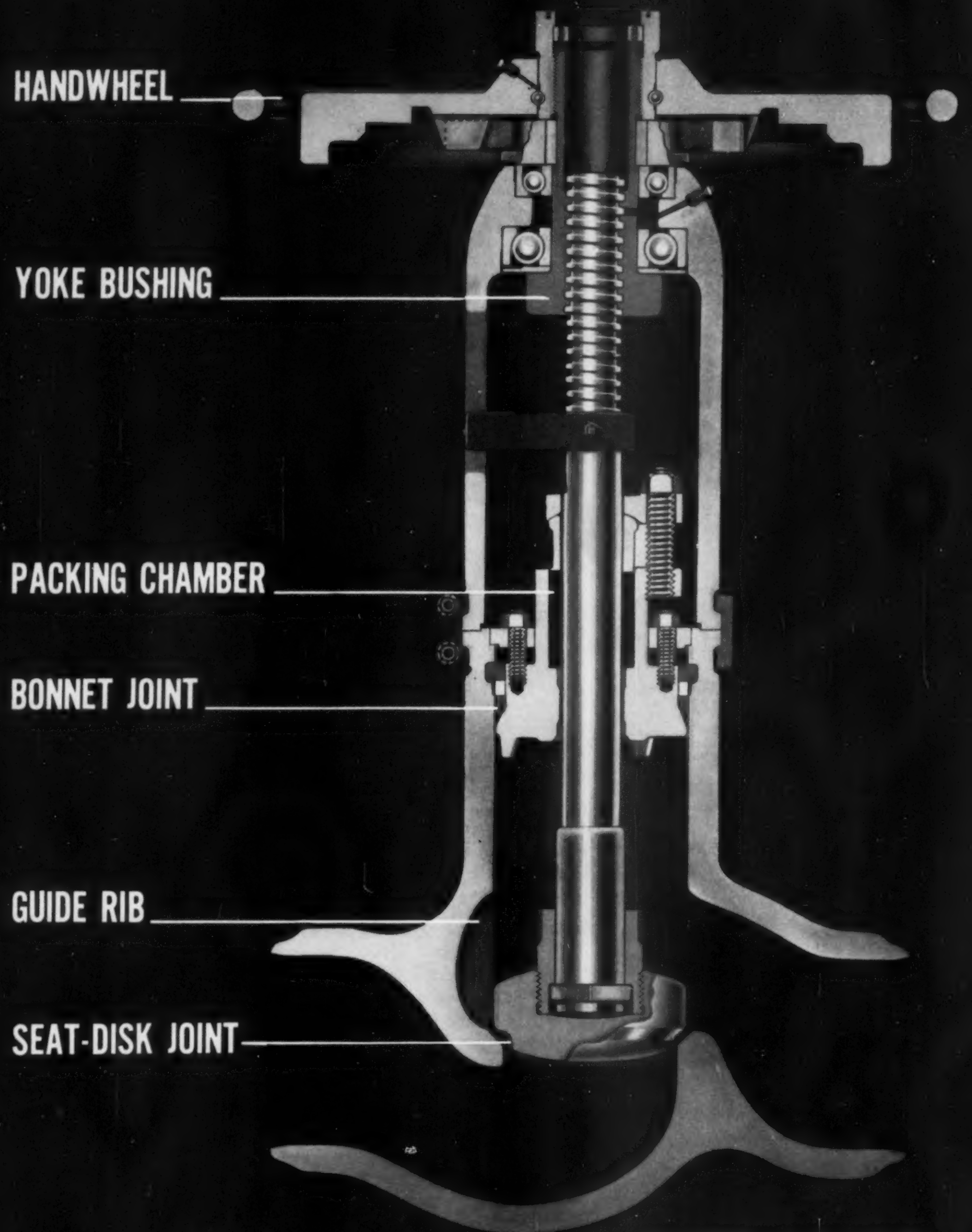
Phone, wire or write Dept. ME for Series 9000 Bulletin.

The Carlyle Johnson Machine Company, Manchester, Conn.

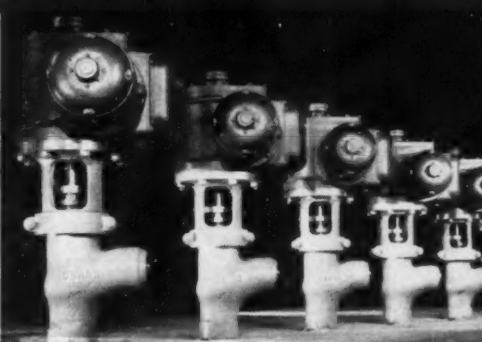
3CJ59



EDWARD CAST STEEL
GLOBE VALVE FIG. 4016Y

IMPACTOGEAR® OPERATED VALVE

MOTOR OPERATED VALVES



What's New from Edward Valves

New Products . . . Solutions to Problems . . . Information on Steel Valves from Edward, Long-Time Pioneer in the Field!

HOW TO SELECT CAST STEEL VALVES

Valves for today's high-pressure processes require economy, dependability and safety in operation. The material on these pages is designed to help acquaint you with a few basic principles and features you should consider when selecting cast steel valves 2½ inches and larger.

VALVE FEATURES FOR LONGER LIFE, EASIER OPERATION

Valve Handwheel should be large enough to operate valve easily. On smaller valve sizes, a knobbed handwheel design permits tighter grip. But for larger, high-pressure valves, impact-type handwheels will increase closing force, insure tighter closure (see large illustration opposite page). Quick closing can be obtained with impact-type handwheels geared for closing with the aid of portable air or electric wrenches (bottom-left, opposite page). Or, where central or automatic control is desired, consider fixed motor operation (bottom-right, opposite page).

Yoke Bushing on larger valves in higher pressure classes should be equipped with double ball-bearing construction for reduced operating torque and effective transmission of closing load (large illustration on opposite page shows this design). Material is important, too. On smaller valves, bushings of bronze will help prevent stem seizing or galling. Look for ample thread engagement between bushing and yoke and between bushing and stem.

Packing Chamber should be large enough to insure long packing life. Valve packing must allow the stem to move within the bonnet but must not allow any fluid leaks between them. Well made packing, formed specifically for the packing chamber and correctly compounded for your pressure-temperature service conditions, has much to do with satisfactory valve performance. Valves with a positive backseat for re-packing while under pressure offer additional operating advantages.

Bonnet Joint of bolted construction (see Fig. 618 this page) is easiest to work with on medium or small size valves. But for lasting bonnet joint tightness, in high-temperature services (and for reduced size and weight), pressure-seal bonnet joint design is best—no flanges or bolting to periodically restress (see large illustration opposite page). Not all pressure-seal designs are alike, however. Avoid gaskets with small sealing surfaces and sharp edges that can be easily damaged and large threaded gasket loading mechanisms that are hard to disassemble and give unknown gasket compression.

Disk Guiding that properly centers the disk into the seat for positive shut-off regardless of position is important. Valve bodies with integrally cast guide ribs supporting disk throughout travel are best. Avoid designs which attempt to guide by installing spider in seat opening.

Seat-Disk Joint—An integral hard-faced seat is generally regarded as superior to screwed seat construction because it eliminates body-seat leakage and retains hardness under temperature. A hard-faced disk or disk of special alloy is desirable in high temperature services; but 13 per cent chromium stainless steel is an excellent all purpose material below 750° F.

Body Design with streamlined flow passage areas (opposite page) reduces wear-producing turbulence, decreases pressure drop and delivers maximum flow. Valves with streamlined body contours will often permit the use of smaller pipe and valve sizes. Angle valves (see Fig. 7517Y, upper right) have even less pressure drop.

For more detailed information, contact your Edward Representative, or write Edward Valves, Inc., 1228 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 360 Notre Dame Street, W., Montreal 1, Quebec.

Edward Valves builds a complete line of cast steel stop, check, non-return, stop-check and gate valves for pressures to 10,000 lbs. available with flanged or welding ends. Below are illustrated a few of the major valve designs from this complete line.

Fig. 7517Y
Angle stop valve, 1500 lb at 850 F. (3600 lb WOG), with integral Stellite seat, Stellited disk, pressure-seal bonnet, welding ends. 2½" to 14".

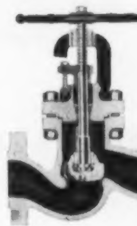


Fig. 618
Globe stop valve, 600 lb at 850 F. (1440 lb WOG), bolted bonnet, flanged ends, integral Stellite seat, Stellited disk. Sizes 2½" to 6".

Fig. 607Y
Angle non-return valve, 600 lb at 850 F. (1400 lb WOG), with pressure-seal bonnet, integral Stellite seat, Stellited disk-piston, welding ends, sizes 8" to 14".

Fig. 611—Gate valve, 600 lb at 850 F. (1440 lb WOG), with hard-surfaced seats and wedge, ball bearing yoke, flanged ends. Sizes 2½" to 12".

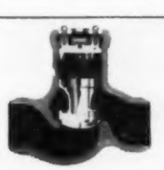


Fig. 4094Y—Horizontal check valve, 900 lb at 850 F. (2160 lb WOG), with integral Stellite seat, Stellited disk-piston, pressure-seal cover, welding ends. Sizes 2½" to 14".

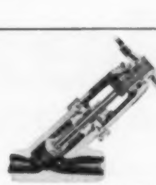


Fig. 7514—Flite-Flow globe stop valve, 1500 lb at 850 F. (3600 lb WOG) or 2500 lb at 850 F. (6000 lb WOG), with extremely low pressure drop and other premium features. Sizes 10" to 18".

EDWARD STEEL VALVES

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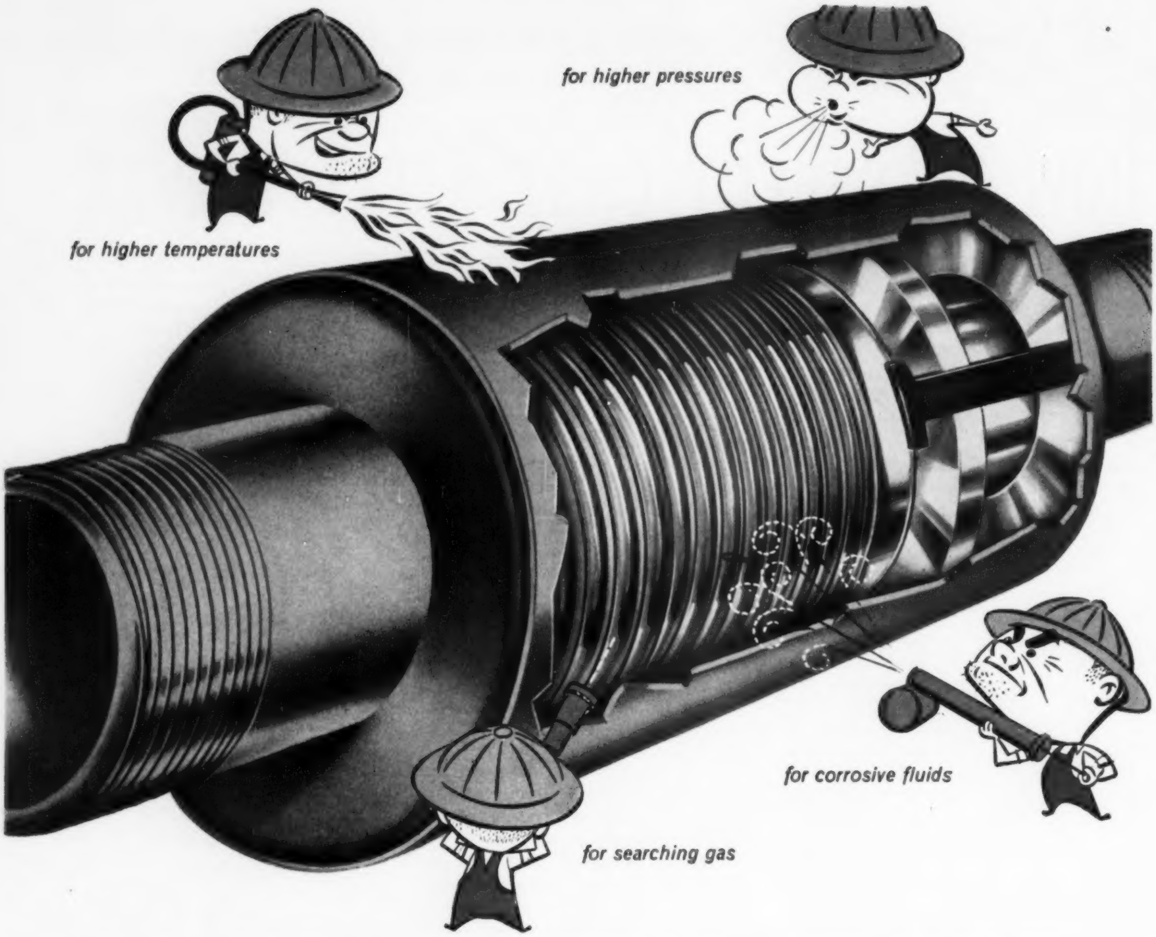
Catalog 14 contains full data on the complete Edward line of forged and cast steel valves from ¼" to 18"; in globe and angle stop, gate, non-return, check, blow-off, stop-check, relief, hydraulic, instrument, gage and special designs; for pressures up to 10,000 lbs: with pressure-seal, bolted, union or welded bonnets, with screwed, welding or flanged ends.



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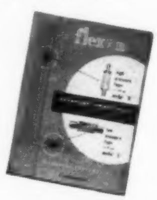

EC-140

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MECHANICAL ENGINEERING

VOLUME 81 • NUMBER 10 • OCTOBER, 1959

ASME Looks Ahead

Less than six months after Hiroshima, ASME organized the Nuclear Energy Application Committee to keep a watchful eye on developments in atomic energy. The Nuclear Engineering Division, established in 1955, is a direct outgrowth of this Committee.

In 1949, ASME organized its Air Pollution Controls Committee . . . "to initiate and co-ordinate research concerning the health, comfort, nuisance, engineering, and economic aspects of the problem . . . .formulate standards. . . . encourage presentation and publication of papers on air pollution."

To provide a means of developing and providing a center of professional activity in the field of solar energy, ASME in 1956 established the Solar Energy Application Committee.

Such was the pattern of the Society's technical growth, its invasion of new engineering fields, its means to satisfy the interests of its members in the period following World War II.

However, a means was needed whereby the Society would be able to take a better look at new developments—developments that loom far over the horizon. Examples: Nuclear fusion, long-range weather prediction, energy storage, and the like. In essence, a new ASME committee was necessary. Its function: To contemplate and anticipate changes in technology so that the Society could formulate plans to meet the coming needs of the mechanical-engineering profession.

By September of 1956 such a committee came into being. On recommendation of the Board on Technology the Executive of the Council authorized the formation of a Technical Development Committee. . . to promote the development of technical activities in the Society by (1) surveying continuously the growth of scientific and engineering knowledge; (2) anticipating the need of technical society activity in new fields; and (3) recommending new group activity to serve the Society's needs in these new fields.

Since its formation back in 1956 the Technical Development Committee has been meeting about four times a year. And with men like Barker, Allen, the two Baileys (E. G. and Alex), Dryden, Kettering, Rowley, Sporn, Warren, and others in attendance at the meetings, the conversation and discussion that flowed were rich in new engineering ideas and covered a span of diversified subject matter. To promote the greatest possible freedom of expression at the meetings, the minutes of the Committee have been issued on a confidential basis—that is, until now. For in "The ASME News" of this issue of MECHANICAL ENGINEERING is the Technical Development Committee story based on the Committee's recently released first Annual Report. In it the perceptive reader will find many interesting ideas, stimuli for future developments, new trends.

For example, energy storage has been discussed a great deal by the Committee, and reports of new electric storage battery developments have been reviewed.

In the automotive field, the Committee has discussed the possibility of using the fuel cell as an energy source for automotive power. The small lightweight electric-drive car has also attracted the Committee's attention.

Power from fusion, magnetohydrodynamics, water resources, air pollution, even algae as a source of food and fuel, have been topics of lively discussion.

The report offers many challenges, especially to the Professional Divisions of ASME, and it is hoped that the Divisions will carry forward and expand any or all of the ideas offered.

As for the Technical Development Committee: Congratulations on a job well done!—*J. J. Jaklitsch, Jr.*

Editor, J. J. JAKLITSCH, JR.

By H. K. Nason[1]
Monsanto Chemical Company
St. Louis, Mo.

Management's CHANGING

SOMETIME within the past 20 years, largely without realizing it, we passed from the "modern" age into a new and as yet nameless era whose characteristics mark it as a major epoch in civilization (Drucker [1]).[2] These characteristics include the virtual elimination of time and space as barriers to communication. They include the acceptance of change—irreversible change—as the normal situation, plus a new concept of life and our universe as an integrated whole rather than a collection of loosely related parts.

As in previous major ages of transition, those directly involved in it are, by and large, unaware of the true significance of the events which are taking place. We continue to apply the old norms of philosophy, politics, society, science, economy, and rhetoric, though they no longer have the same meanings. We have not yet crystallized the new expressions, definitions, and concepts which eventually will become accepted as characterizing the new age.

Yet we are committed to our new age, and can no more retreat to the one so recently left behind than we can reverse the inexorable order of life and grow young again. The purpose, here, is to examine the new era's effect on the management of our technological civilization—an examination which will spotlight the changing responsibilities of management.

Pride Versus Group Effort

As an example, we seem to be uncovering evidence that there must always exist a dualism between organized effort and individual fulfillment, and that maximum efficiency of the former may be antithetical to maximum realization of the latter. As Drucker observes [2], it is interdependence which most accurately characterizes a "system." Dedication to the joint objectives requires a balanced, adjusted, and integrated effort, rather than maximum efficiency of each individual's own contribution.

Professor Hilbert Schenck, Jr. [3], calls specific attention to the effect of this dualism on the engineer, who on the one hand prefers to work on strictly technical matters, yet on the other hand wishes to be considered a manager. The provision of the dual requirements of creative atmosphere and status is one of the most important responsibilities of technical management today.

Thus we might conclude that management's task in this area has changed from that of simply achieving maximum efficiency to that of recognizing and attaining maximum efficiency for the over-all system while retaining to a practical degree the willingness of each individual concerned to contribute his constructive effort.

I do not think that we can be satisfied to accept this as the necessary final state, but rather that our roles as technical managers must include a continued responsibility for further development, for change, and for innovation in this area, to the end that the maximum of individual effort may be utilized efficiently, and that the maximum return in individual satisfaction through pride, recognition, and reward of accomplishment may be realized for the participants. The truly innovative mind is rare, hence must be both encouraged and rewarded [4].

Yesterday's Manager

Time was, and not so long ago, when a manager was the member of an enterprise who knew exactly what needed to be done and who demonstrated to others exactly how to do it. Today, this seems simple, yet from a relative standpoint it was surely as difficult to achieve then as is competence in the much more complex task of contemporary management. The establishment of objectives, the evaluation of performance, and the apportionment of the inevitable rewards of success or penalties of failure were involved then as now, though admittedly on a much more direct and informal basis. Working groups generally were small, and interpersonal relationships tended to be direct and forthright. The "span of control" was limited.

We have learned much about the motivation of individuals and of groups, the organization of groups into complexes, the control of large and far-flung organizations, the co-ordination and planning of multiobjective enterprises, and the extension of the management function into government, agriculture, and social organizations as well as industry and commerce. Such learning often is said to have resulted in a "science of management."

Yet, in a realistic sense, no true science of management exists today. Rather, we may be said to have perfected improved techniques of management, and to be seeking still the underlying relations of cause and effect.

Changes Come Faster and Faster

A characteristic of the transition period in which most of us have spent out adult lives is the rate of change of our environment. J. D. Williams of the RAND Corporation [5], and Girard Piel, publisher of *Scientific American* [6], have published papers on the phenomenal upswing of technical knowledge, bringing it into focus in terms of life spans and the history of man in time perspective.

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[1] Vice-President, General Manager Research and Engineering Division.

[2] Numbers in brackets designate References at end of paper.

Condensed from an address presented at the Management Luncheon during the Semi-Annual Meeting, St. Louis, Mo., June 14–18, 1959, of The American Society of Mechanical Engineers.

In this era, change is the normal situation—scientific, economic, political, and social change. It will come, and part of management's growing responsibility is to provide leadership in the new directions.

RESPONSIBILITIES

Another measure of the rate of change of our technology is provided by Sir Charles Darwin [7] who points out that of all of the large quantities of minerals which have been mined since man first began to take them from the earth, half have been extracted since 1923. Thus the extraction of coal, oil, copper, and the like during the past 35 years matches "the whole of human history in this matter."

Energy production is another criterion of technical development. Looking at electrical generation alone, today's U. S. capacity of 140 million kw, or roughly 1 kw per American, is predicted by Krieg of Stone & Webster [8] to reach 370 million kw by 1979.

Or here is another way to look at it. More than 90 per cent of all of the scientists and engineers who have ever existed are alive today.

Since technological development generally is built on that which has been achieved before, the rate of innovation forms a steeply ascending curve. As Piel so beautifully expresses it, "As man's understanding deepens, his environment grows evermore responsive to his wants; the world's resources become as rich as his imagination."

The point is that management today lives in an era of bewildering plenty. Technical innovation not only has placed new tools at our disposal, it has made survival dependent upon our intelligent use of them. New energy sources; new metals, ceramics, and polymers; new techniques of construction and design; new communication resources, and the application of mathematics and physics to the management process itself—all must be employed effectively. The electronic computer alone has provided us with the capability to solve problems which previously could be solved only by prohibitive investment of time, if at all, and has enabled quantitative evaluation to replace intuitive judgment in areas where only "experience" previously existed as a guide.

In effect, some phases of management, as of other tasks in technology, are passing from an individual art to a state which meets Kelvin's requirement of measurability. Such a transition always is difficult for those concerned, but most of all for the practitioners whose "art" constitutes their unique contribution and who cannot adapt themselves to a more impersonal quantitative situation.

Know-How Isn't Enough

The value of direct knowledge and experience per se as a basis for decision is decreasing. In the future, management more and more must employ effectively techniques and information which it does not really understand, must be sage enough to know when, and when not, to depend upon past actions as a guide, and must be able to adapt itself to the critical requirements of an expanding environment. Grant us the wisdom to remove ourselves from key positions when critical introspection reveals that we are no longer capable of such adaptation.

For we must realize that no longer are we entirely free to choose our own rate of change, nor to choose that for any organization for which we are responsible. The initiative is not necessarily ours, and pressures over which we have no control—technical, economic, political, social—domestic or from abroad, may dictate the direction we must move and the speed. At the turn of the century an enterprise which stagnated still might survive a generation of such nonmanagement, or perhaps even two. Today, five years can ruin an enterprise—or a civilization.

Thus today's concept of technical management requires first that we recognize what is happening to us and that we no longer are completely masters of our own destinies. Then, we must be able to recognize the new technologies whose effective employment is essential to us, to establish the goals for their use in our particular business, to develop an organization including those whose firsthand knowledge is equal to the task, to see that responsibilities are properly assigned, to assure that adequate resources, guidance, and co-ordination are provided, and to continually re-evaluate, reassess, and reorient as needed to remain at least abreast, and preferably ahead, of the tide of technological change.

Nontechnical Areas

The rush of technology is irresistible, and leaves management no choice but to use it effectively or to be swept away by it. In nontechnical areas, this is even more true. Political and social tides, fed by the flood of technology, exert pressures which management cannot ignore save at the peril of perishing under them. These

pressures, which we might formerly have considered "outside" the scope of management, must be contained, or where uncontainable, adjusted to, if the American way of life is to continue in a form resembling in any way that which we know today.

The most obvious example is the communist tide, which certainly is running full in most of the world today. Yet, how appalling is our ignorance of its roots and intentions, though its founders and present leaders have clearly expressed them in writing for all who will to read, and have never yet deviated from them. We continue to deal from a base of ignorance. Education to the nature of Marxist-Leninist Communism, and the employment of this knowledge in all of our administrative activities, not just in our political maneuverings, is crucial to our survival.

Another problem is one to which technology has contributed richly. This is the problem of an explosion in population. Sir Charles Darwin has pointed out that the world population stood at around 300 million at the beginning of the Christian era, and that this had grown only to around 500 million by 1700. In the two and a half decades intervening, this population figure has grown to the present two and a half billion, and is increasing at the rate of 45 million per year.

To put this in perspective, this rate of increase means 100,000 additional human beings in the world every 24 hours. In the hour or so that we have been in this room, around 5000 new lives have come into the world, clamoring to be fed, clothed, housed, and amused.

By the end of this century, world population will be at least five billion. Something over 250 million of these will be Americans. Technology has contributed to this exponential situation by greatly extending the life span, reducing mortality among infants and the aged, and by making more of the necessities of life available to those who can afford to pay for them.

Our Little Island

Today, Western civilization stands on a relatively small island surrounded by a fierce and hungry horde whose numbers are increasing daily. Technology, by erasing time and distance, has enabled these people to know that poverty and starvation are not necessarily the normal states of life. All of them have awakened needs and awakened hungers whose fulfillment cannot long be denied them.

The problem here is twofold. First, if we try to isolate ourselves in the midst of a world clamoring for more of life's necessities, we inevitably will be swept away by the burgeoning horde. Only by aiding the rest of the world to achieve a higher standard of living may we even hope to survive.

Yet, this must be accomplished during a period when the total demands of the world, including our own small sector of it, are increasing at a very rapid pace. To insure the world more may require, sometime before the end of the century, that we learn to get along with less, but this may be the price of survival at all.

Is it not significant that today we have in this country agricultural surpluses whose mere storage is an onerous burden to us, while three quarters of the world exists with a daily caloric intake roughly two thirds of that considered minimum for a normal life? The stores of surplus foodstuffs which we will have on our hands by the end of the current growing season will be sufficient to provide the additional thousand calories per day needed for a minimum nutritional level for all of the rest of the world. Yet, in the face of this abundance, we struggle in vain for a solution.

Management no longer can stand aloof from these broad problems, of which technology is but one facet. Rather, management, for enlightened self-interest if for no other reason, must take an active part in efforts toward their solution.

And the resources of technology will play an important part in all phases of this program. The electronic computer, which has produced such great changes in our technology and in the management of it, also possesses tremendous potential for application to problems formerly considered incapable of mathematical evaluation. That our Russian competitors are well aware of these potentialities is clearly brought out by their highly competent program for the application of matrix mathematics in evaluating the performance of the Soviet economy and in charting economic paths for future growth [9].

Social Implications

The scope of management no longer can ignore the nontechnical consequences of its own efforts, but must increasingly be concerned with implications. This absolutely requires that management employ economic, social, and political data in its studies, and further that management join other informed and well-intentioned people toward the solution of our nontechnological problems. In other words, the next step is a further integration of our environmental system into an engineered system utilizing everything most efficiently.

Just as we attack a technological or management problem at the most simple identifiable level, so we must attack this more complex problem at the nearest point where it can be grasped. In the case of our American system, this is the point closest at hand, namely, our local environment. From here, we can proceed logically to the more complicated state and national systems. Only if these can be put in order may we have any hope of ever achieving an orderly system of worldwide scope.

The understanding and acceptance of these changing responsibilities requires even keener intelligence than we now possess, and intelligence can be sharpened only by education. The areas demanding attention lie clearly marked before us, and this attention is a matter of urgency and concern. The time is now. Tomorrow will be too late.

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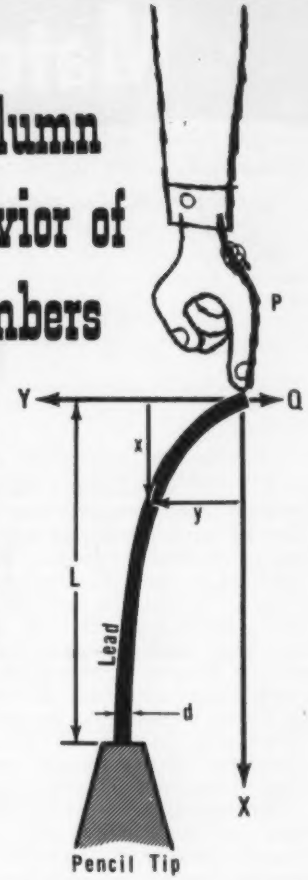
9 St. Louis Post-Dispatch, May 23, 1959, p. 1.

By Highway Research Engineer, University of Virginia, Charlottesville, Va., **William Zuk, PhD**

Beam Column Behavior of Brittle Members

Science takes a bold step, bringing new hope to engineers who have something they ought to write down. You, too, can install a new lead.



A MORE accurate, although less dignified, title to this article would perhaps be: "What Happens When You Try to Stick a New Piece of Pencil Lead Into an Automatic Pencil and the Lead Snaps Off?" There must be countless thousands of such breakages the world over every day. This brief paper is therefore written to better understand the mechanics of such destructive processes.

Laboratory experiments show that, in the process of inserting a new piece of graphite into an empty pencil, rupture occurs not by the axial buckling force P but by lateral force Q at the free end (see Fig.). The forces of insertion are all assumed to act at the free end, as would be if the lead is inserted by a push at the end from a finger or other object. This alignment represented the most critically dangerous orientation.

The controlling differential equation is

$$EI\,\frac{d^2y}{dx^2} = -Py - Qx \qquad (1)$$

where E is the modulus of elasticity and I is the moment of inertia. The general solution to equation (1) is

$$y = A\sin kx + B\cos kx - \frac{Qx}{P}$$

where $k = \sqrt{\frac{P}{EI}}$ and A and B are constants to be determined by boundary condition as follows:

$$y_{(x=0)} = 0$$

$$\frac{dy}{dx_{(x=L)}} = 0$$

The completed solution is therefore

$$y = \frac{Q}{Pk}\,(kx\cos kx + \sin kx - kx) \qquad (2)$$

From equation (2) the maximum deflection is

$$y_{(x=L)} = \frac{Q}{Pk}\,(kL\cos kL + \sin kL - kL) = y' \qquad (3)$$

The maximum moment is at the pencil point and equals

$$QL + Py' = \frac{Q}{k}\,(kL\cos kL + \sin kL) = M'$$

Since the material is brittle, the rupture tensile stress s of this brittle material governs the snapping mechanism.

The maximum tensile stress is

$$\frac{M'}{z} - \frac{4P}{\pi d^2}$$

where z is the section modulus.

After making the appropriate substitutions and solving for the limiting value of Q, noted as Q'',

$$Q'' = \frac{k\pi d^3 s + 4Pbk}{32\,(kL\cos kL + \sin kL} \qquad (4)$$

Substituting equation (4) into (3), the limiting deflection allowed at the end of the pencil lead is therefore

$$y'' = \frac{\pi d^3 s + 4Pd}{32\,P}\left(1 - \frac{kL}{kL\cos kL + \sin KL}\right) \qquad (5)$$

Based on laboratory tests, using the author's "thin line" graphite and a slightly used pencil, the following characteristic values were obtained:

L = 6.85 cm
d = 0.093 cm
s = 1480 kg/sq cm
E = 7.9×10^5 kg/sq cm
P = 0.01 kg

Equation (5) therefore predicts that the free end may be displaced only 0.258 of a centimeter before rupture occurs and one has to start all over again picking up the pieces. The order of magnitude of this limiting value is obviously too small for indiscriminate handling, especially for individuals below the age of twenty-one. In conclusion, it therefore seems that herein lies an area of behavior ripe for a technical breakthrough, second in priority only to the need for a cigar with better structural characteristics so that it will not rupture in one's coat pocket.

Not contributed by any Professional Division and not to be presented at the Annual Meeting, November 29–December 4, 1959, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Materials for Service Above

Limitations in existing materials are now a major determinant of trends in design. There is a growing recognition that materials, environment, and design must be viewed as an integrated system.

METALS and CERAMICS

By Julius J. Harwood[1]

The number and complexity of high-temperature applications continue to grow, and the limitations of existing materials have become a major determinant of trends in design. The high-temperature capabilities of available alloy systems are summarized in Table 1.[2] It may be noted that the nickel and cobalt alloys, which form the bulk of present superalloys, are now being used at almost 80 per cent of their melting points. Because there is little chance of significantly extending the useful temperature range of these materials: (*a*) Higher-melting alloy systems, such as the refractory alloys, must be used; (*b*) thermal-protection and heat-alleviation systems must be employed, involving new types of materials and new design concepts.

The thermal properties of materials are now receiving equal, and sometimes greater, emphasis than the high-temperature-strength properties. Specific heat, heat transfer, thermal conductivity, coefficient of thermal expansion, and similar properties are becoming important criteria. Much attention also is being focused on the development and use of composite materials and thermal-protection systems for heat alleviation.

Fortunately, the severe temperature requirements for missiles and hypersonic aircraft are mitigated somewhat by the short operating times frequently involved. Times of exposure at high temperature range from seconds to a few hours as compared to hundred and thousand-hour requirements of more conventional high-temperature systems. This permits the use of some materials at 5000 F that would otherwise be impossible.

Intermediate-Temperature Materials (1000 to 1500 F)

Titanium. Discussion must begin with titanium. The relatively low melting points of aluminum and magnesium preclude their use much above 800 F without structural design concepts involving thermal protection. With the use of such systems, however, they cannot be ignored completely even when discussing skin temperatures as high as 3000 F.

A realistic appraisal indicates that titanium alloys are important structural materials at temperatures as high as 1200 F, and perhaps to 1500 F for short exposure times. Their high strength-to-weight ratio and ability to retain strength properties at elevated temperatures, Fig. 1, have placed them in an attractive competitive position for a wide variety of sheet applications. The Department of Defense Titanium Alloy Sheet Rolling Program has brought about the production of new, superior, high-quality sheet alloys suitable to about 800 F, Table 2, and the cost of titanium is steadily declining. New alloys, such as the Crucible all-beta B120VCA alloy, 13V-11Cr-4Al, and the Mallory Sharon Alloy of 8Al-8Zr-1Cb, show promising properties at temperatures up to 1200 F. Some of the particular virtues of the all-beta alloys are formability, ductility, and weldability. These newer alloys are promising for composite structures such as honeycomb cores.

Even the best titanium alloys have only been able to approach service temperatures of about 45 per cent of the melting point of titanium, Table 1. This inability to retain high strength at higher temperatures is a disappointing anomaly. It is not certain at this time whether this reflects basic material properties or an immaturity in alloy development, but it does hold out the possibility of extending the temperature capabilities of titanium alloys to the same fraction of melting point as is true for other metal systems.

High-Strength Steels. High-strength steels are probably the most widely used rolled-sheet materials for temperatures up to 1200 F in advanced aircraft, missiles, and rockets. The hot-work die or tool steels, martensitic stainless steels of the 400 series, low-alloy steels such as modified 4340, transformation and precipitation-hardening semiaustenitic steels, cold-worked austenitic steels, and precipitation-hardening austenitic steels are all receiving much attention. Some representative strength properties are shown in Fig. 2.

The hot-work die steels based upon the 5 per cent chromium compositions, which until recently were not considered as structural materials, are now available as

[1] Head, Metallurgy Branch, Office of Naval Research, Washington, D. C. Condensed from Paper No. 59—MD-2.

[2] Taken from a paper by L. P. Jahnke and R. G. Frank, *Metal Progress*, vol. 74, November-December, 1958, pp. 77, 86.

Based on two papers contributed by the Machine Design Division and presented at the Design Engineering Conference, Philadelphia, Pa., May 25-28, 1959, of The American Society of Mechanical Engineers.

1000 F

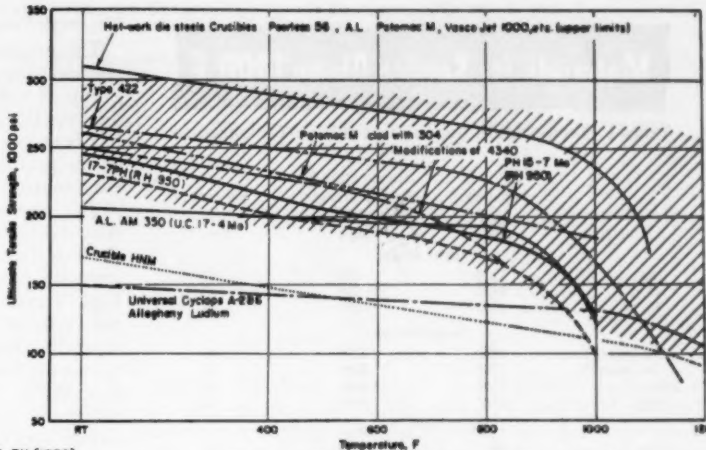


Fig. 1 Ultimate tensile strengths of various alloys as a function of temperature

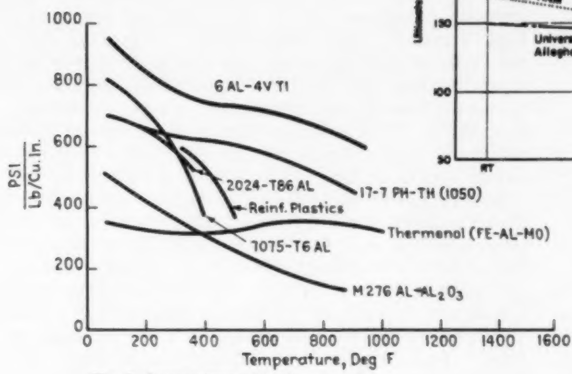
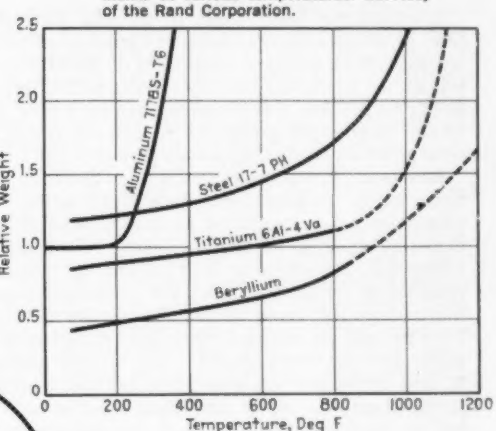


Fig. 2 Comparison of typical tensile strengths of presently available steels with airframe and missile requirements. Courtesy of Defense Metals Information Center.

Fig. 3 Relative weight of tension elements at various temperatures. Courtesy of the Rand Corporation.



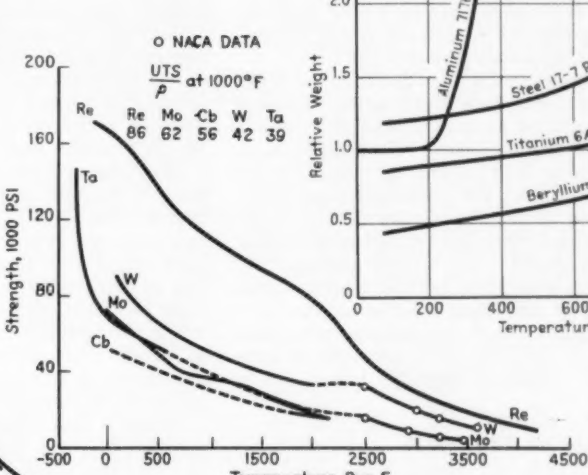


Fig. 4 Tensile strength of refractory metals. Courtesy of the National Aeronautics and Space Administration.

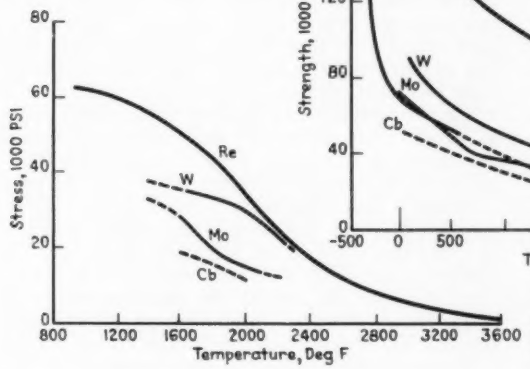


Fig. 5 Stress-rupture strength of refractory metals. Courtesy of J. Pugh.

sheet, plate, and other semifinished mill products. They exhibit impressive strength properties up to about 1000 F, for example, 150,000 psi tensile strength at 1000 F, and the highest strength-to-weight ratio of any commercially available alloy. However, heat-treatment, fabrication, and welding difficulties are currently limiting their use.

The stainless steels, particularly the precipitation-hardened, semiaustenitic stainless types, while not as strong as the hot-work die steels, have a better balance of properties and are finding wide acceptance at strength levels as high as 225,000 psi. Forming and welding are accomplished in the ductile austenitic condition, followed by appropriate heat-treatment. They have satisfactory corrosion and oxidation resistance, which is a distinct advantage over the tool steels. Indeed, development work is under way for the cladding of the low chromium steels with superior corrosion-resistant austenitic alloys to meet severe environmental problems.

The martensitic stainless steels, containing about 12 per cent chromium, can be heat-treated to strength levels which closely approach those of tool steels. But fabrication and corrosion problems make it unlikely that they will find widespread structural applications.

Materials for Service Above 1000 F

Table 1 Temperature Capabilities of High-Temperature Materials

Base metal	Melting point, deg F	Temperature for useful strength of best alloys,[a] deg F	Per cent of melting point[b]
Light Alloys			
Mg	1200	650	67
Al	1220	550	60
Ti	3100	1200	46
Superalloys			
Fe (mart.)	2800	1350	56
Fe (aust.)	2800	1600	63
Ni	2650	1960	78
Co	2720	1900	74
Refractory Alloys			
Cb	4470	2200	54
Mo	4760	2650	59
W	6170	2550	45

[a] Withstands 10,000 psi for 100 hr.
[b] Per cent of absolute melting point at which alloy is useful.

Attempts are being made to use the controlled features of metallurgical structure to produce steels exhibiting short-time strength properties of 350,000 to 500,000 psi at as high as 1200 F. Since such high tensile strengths involve low tempering temperatures, large decreases in strength properties will occur at higher temperatures for sustained exposure periods.

Beryllium. Beryllium is another newcomer to the high-temperature structural-materials field whose thermal properties have already led to consideration for use as a heat-sink material in missile systems. From a structural viewpoint, considerable interest has been aroused because of its low density, 1.8 g per cc; its very high modulus of elasticity, above 40,000,000 psi; its melting point, 2343 F; and its strength-retention properties at moderately elevated temperatures. The weight savings, Fig. 3, and increased stiffness potentialities which would accrue from the use of beryllium-sheet structures have led to intensified research and development programs. Particular emphasis is being placed on attempts to solve the major technical difficulty, namely, low ductility and brittleness.

High-Temperature Materials (1200–1800 F)

The superalloys, that is, the nickel, cobalt, and iron base alloys used so extensively for gas-turbine materials, will continue to provide the bulk of the heat-resistant materials within the 1200 to 1800-F range. The outstanding development in this field is the availability of nickel-base-alloy compositions with useful capabilities at about 1800 F, even under high-stress conditions. Increased knowledge of the precipitation reactions and metallurgical behavior, and large-scale vacuum melting, have been combined to produce these improved high-temperature-strength alloys which are finding extensive use as castings and forgings for engine applications and for sheet-metal applications. Related developments in cobalt-base alloys are also in progress.

Despite these improvements, we are rapidly approaching the temperature limitations of these alloys and only marginal improvements can be anticipated. For operation above 2000 F, higher-melting-point alloy systems must be developed.

Ultrahigh-Temperature Materials (above 2000 F)

The greatest hope for developing alloys for very-high-temperature applications appears to lie within the group of refractory metals, Table 3. Of these, molybdenum-alloy development is the most advanced and has been one of the most significant alloy achievements of the past decade. These still exhibit the best over-all combination of properties for high-temperature service.

The success of the molybdenum-alloy programs has stimulated major research interest in the entire group of the refractory metals, whose chief value is their high-strength properties over a wide range of temperatures, Figs. 4 and 5. The strength level, in general, follows the order of melting point, and the same is true for recrystallization and resistance to recovery, which are important factors in determining high-temperature-strength properties. This striking relationship between melting point and high-temperature strength makes obvious the advantages to be expected from more refractory alloys.

Jahnke and Frank[2] have tabulated the advantages and disadvantages of the refractory metals which led to the generalization that the higher oxidation resistance and lower density of columbium make it the most attractive of these metals up to 2500 F. Up to 3500 F, molybdenum alloys will prevail and above this temperature, to about 5000 F, tungsten-base alloys appear to be the remaining hope. From a purely oxidation point of view, the refractory platinum alloys, such as rhodium and iridium, deserve serious consideration.

Detailed investigation of the mechanism of strengthening molybdenum-titanium alloys has revealed that a potent factor promoting high-temperature strength is the presence of dispersed-carbide phases, Table 4. This recognition is leading to development of a new series of Mo-Ti-Zr alloys with higher carbon contents.

Molybdenum-rhenium alloys, containing 35 atomic per cent rhenium, display the extraordinary combination of properties of cold ductility (cold reducible from the as-cast state up to 95 per cent), low transition temperature, high recrystallization temperature, and high strength. The as-cast ductility and low transition temperature of these Mo-Re alloys suggest their use as weld-filler metal. While the molybdenum-rhenium alloys may be classified as exotic and expensive, and rhenium seems to be unique in its properties, a more readily available substitute to accomplish the same effect is being sought.

Intensive investigation of columbium-base alloys has revealed that it is not as simple as originally anticipated to overcome the lack of oxidation resistance. Oxidation-resistant alloys have been developed in the laboratory, although, in general, the desirable characteristics of oxidation resistance, high-temperature strength, and fabricability are not readily exhibited by any one alloy.

However, information recently released by General Electric indicates some remarkable success with alloys which exhibit a rupture strength at 2000 F of 35,000 psi in air as compared to 37,000 psi in vacuum. The 100-hr rupture strength in vacuum is about 30,000 psi at 2000 F.

On obvious implication of the remarkable retention of strength in an oxidizing atmosphere is the possible use of such materials, uncoated, for short-time service (10 hr). Engineering data are becoming available on other alloys, such as the du Pont Cb-10Ti-10Mo alloys. Attractive oxidation resistance at 1800 F and good workability characteristics have been reported for 45Cb-50Zr-5Ti alloys.

Table 2 Typical Tensile Properties of Titanium Sheet Alloys Now in Commercial Development

	Mechanical Properties					
	Room temperature			800 F		
Alloy	Ultimate tensile strength, 1000 psi	Yield tensile strength, 1000 psi	Elongation, per cent	Ultimate tensile strength, 1000 psi	Yield tensile strength, 1000 psi	Elongation, per cent
DOD[a] target properties	180	160	10	130	105	15
DOD[a] sheet-rolling program alloys						
Ti-6Al-4V	170	155	10	115	100	10
Ti-16V-2.5Al	170	160	5	130	120	7
Ti-4Al-3Mo-1V	170	150	10	100	110	15
				600 F		
Higher-strength alloys						
Ti-13V-11Cr-4Al	200	180	5–8	142	125	6
	240	220	2–4	..	..	..
Ti-1Al-8V-5Fe	205	193	6	153	130	7

[a] Department of Defense.
Courtesy of Defense Metals Information Center.

Major engineering problems, nevertheless, remain to be solved before there will be widespread use of the refractory alloys. Lack of oxidation resistance is most serious, embrittlement by gases, weldability, and fabricability are other serious problems whose complexity increases as the melting point increases. However, even in the case of molybdenum, reasonable strides have been made in the development of coating systems and techniques for long-exposure oxidation protection. A new type of diffusion coating has withstood several hundred hours of oxidation exposure, without failure, at 2350 F, even after prior bending of the samples. Satisfactory short-time exposures have been reported up to 3500 F, and apparently good thermal-shock resistance and good erosion resistance in extremely high-temperature, high-velocity gas streams. For a number of applications, the key to the problem lies in evaluation of already developed coatings for specific components and tailoring the coating and application techniques to the specific design and service requirements. A General Electric jet engine using coated molybdenum turbine blades has been experimentally operated with turbine-inlet temperatures in excess of 2000 F.

Fabrication problems involve quality, reliability, availability, sizes, tolerance, and weldability. The possibility of initiating a refractory-metal sheet-rolling program, similar to but smaller than the Department of Defense program on titanium is now receiving serious consideration.

A related problem is the need for facilities to enable true hot-working of the refractory alloys which exhibit high recrystallization temperatures. Hot-working of metals and alloys usually is accomplished at temperatures between 0.6 to 0.8 of the melting point. On this basis refractory metals should be worked at about 3600 F, although molybdenum and tungsten are worked below this true hot-working range. This is a serious deterrent to exploitation of the strength properties of refractory alloys.

One step in this direction is the creation of a 150,000-cu-ft argon-filled plant by the Universal-Cyclops Steel Corporation (in co-operation with the Department of the Navy) in which a rolling mill, an impact extruder, welding equipment, and other fabricating equipment will be capable of operating at least to 3650 F. With the availability and capabilities of true hot-working facilities, it is conceivable that alloys might be developed exhibiting strength properties in excess of 100,000 psi above 2000 F.

Cermets and Ceramics. Despite the concentrated attention of the past ten years on metal-bonded carbides, borides, oxides, silicides, and nitrides, primarily for gas-turbine use, little consideration is currently being paid to cermets for high-temperature structural applications. The most highly developed cermet compositions were the cemented titanium-carbide grades containing nickel-base alloys as binder. The chromium-boride cermets using chromium-molybdenum alloys as binders and the chromium-molybdenum-alumina compositions also achieved a high state of development.

These cermets exhibited impressive strength properties up to about 2000 F, superior to the superalloys. However, general lack of ductility, low notch sensitivity, low impact resistance, and erratic thermal-shock resistance make them generally unfit for aircraft-gas-turbine usage, except in special cases where cautious design and small sizes are possible. Small gas-turbine wheels are an example, with high heat input and high-temperature service involved. These have been successfully spin-tested in preliminary runs.

Cermets and ceramic materials are currently being developed for rocket nozzles and related guidance components. High thermal shock resistance, thermal stability, oxidation, and erosion resistance are prime requirements. Numerous compositions based upon borides, nitrides, oxides, and silicides show interesting behavior. Fabrication of large-size components still presents a major

Table 3 Refractory Metals

	Melting point, deg C	Density, g/cc	Young's modulus, 10^6 psi	E/P 10^6
Tungsten	3410	19.3	50	2.59
Rhenium	3180	20.0	67	3.35
Tantalum	2996	16.6	27	1.63
Osmium	2700	22.5	80	3.51
Molybdenum	2625	10.2	45	4.41
Ruthenium	2500	12.2		
Iridium	2454	22.5	75	3.33
Niobium	2415	8.57	15	1.76
Rhodium	1966	12.4	41	3.31
Chromium	1890	7.19	36	5.0

Table 4 Effect of Ti and C Content on Strength Properties of Molybdenum-Titanium Alloys

Analysis				
Ti, per cent	C, per cent	C/Ti × 10^{-2}	Tensile strength at 1600 F, psi	Stress rupture in 100 hr, psi
0.47	0.004	0.9	18000	10500[a]
0.44	0.019	4.3	35700	30500[a]
0.47	0.022	4.7	36600	31000[a]
0.45	0.14	31.1	38200	33000
1.22	0.014	1.1	23100	17500
1.20	0.028	2.3	33900	20500
1.26	0.036	2.9	45900	38000
1.36	0.060	5.9	55300	50000
1.20	0.14	11.7	59100	53000

[a] Estimated from incomplete data.

Materials for Service Above 1000 F

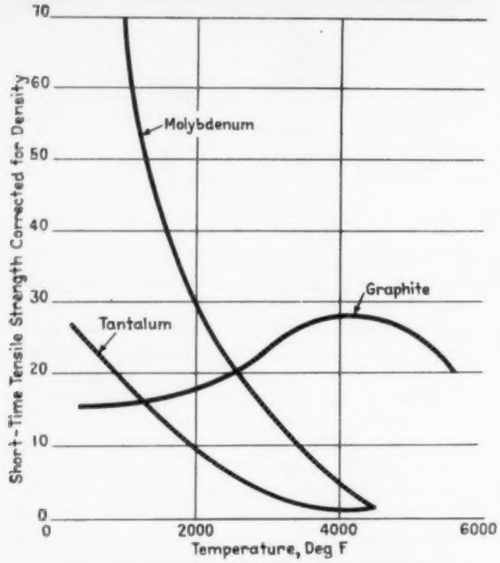


Fig. 6 Strength properties of graphite, as a function of temperature. Courtesy of **Metal Progress.**

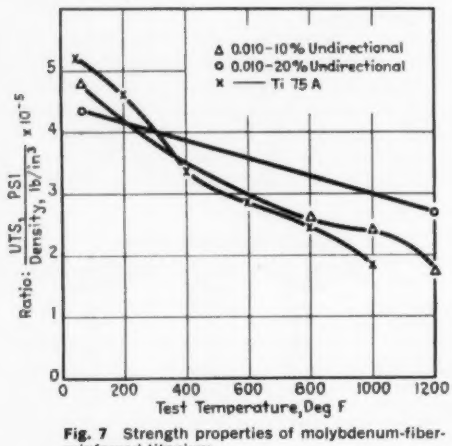


Fig. 7 Strength properties of molybdenum-fiber-reinforced titanium

difficulty, although some recent preliminary success with slip-casting techniques offers some hope for the future.

Pyrocerams and alumina are also receiving much attention for radome and similar guidance applications where high Mach numbers and high temperatures are involved.

Another material which has attracted widespread attention is graphite. Its low density, good thermal shock resistance, and high sublimation temperature (about 7000 F) have led to its use or consideration for such applications as rocket nozzles, vanes, jetavators, and nose cones. Above about 4500 F, graphite has superior strength properties to molybdenum and other refractory metals, whose properties deteriorate rapidly as their melting points are approached, Fig. 6.

The major drawbacks are poor oxidation and erosion resistance, but notable improvements have been reported through the use of silicide and carbide coatings. For short-time applications, in appropriate environments, the degree of surface degradation of unprotected graphite does not interfere with satisfactory performance. Reproducibility and high quality are also problems with commercial grades of graphite, and serious efforts are being devoted toward the development of special missile grades.

One of the promising new events in ceramics research has been the demonstration that an appreciable degree of ductility can be obtained in single crystals of ionic solids and certain oxides by proper control of purity and environment and by special surface treatments. Whether polycrystalline oxides and other refractory compounds can be produced with the proper compromise of strength and ductility characteristics remains to be seen.

Thermal-Protection Systems

Such thermal-alleviation schemes as ablation and sublimation coatings; transpiration, film, or liquid-metal cooling; heat sinks; and insulating layers are being used to prevent the heat flux from penetrating to the primary structure. Materials development and selection for such applications obviously differ from more conventional design practice. It is necessary to emphasize those properties which either increase the time lag before attainment of equilibrium temperature or lower the temperature generated in the material by its environment. Such properties as thermal capacity, emissivity, thermal conductivity, and coefficient of thermal expansion assume new importance. Mechanical properties for short exposure times at temperatures are also involved.

Composite Materials

Thermal-protection systems emphasize the fact that no single material has the range of complex properties associated with many high-temperature applications. Therefore, composite materials and structures are being developed. Reinforced plastics and honeycomb sandwich constructions are conventional examples; others range from pure metals containing finely dispersed oxide particles to ceramics containing metal fibers and meshes.

It has been demonstrated that metal and oxide whiskers can be grown with strength properties approaching theoretical values of atomic cohesion, but practical exploitation of their tremendous strength, either by themselves or in composites, poses a challenge. Glass-fiber-reinforced aluminum, molybdenum-fiber-reinforced titanium, Fig. 7, and others have shown that this reinforcing technique is quite capable of increasing the high-temperature-strength capabilities of materials. Indeed, a new field of "fiber metallurgy" has come into existence.

Fine-particle strengthening is a related approach. Extension of the sintered-aluminum-powder principle to other metal systems, particularly the high-melting-point metals, has already produced striking results. Work on nickel, copper, and molybdenum-containing finely dispersed phases has shown that there is a real hope for developing new types of simple alloys capable of exhibiting thermal and mechanical stability at temperatures approaching their melting points.

Simple or complex multilayer composite construction

such as the use of adhesive-bonded ultrastrength steel strip or wire, appears feasible for efficient and safe use of material at over 300,000 psi. Prestressed ceramics are another possible goal.

Processes

Certainly one of the major developments contributing to progress in improved materials has been the ability to melt higher purity materials resulting in higher strength, better ductility, improved fatigue resistance, and better fabricability.

Vacuum and controlled-atmosphere melting, on a production scale, has been a significant factor. Melting and refining techniques involving electron guns, zone refining, and levitation melting have permitted substantial progress. Solar and arc-image furnaces, plasma jets, and other new facilities now allow the melting of materials which previously required powder-metallurgy practices.

Explosive forming and shaping, ultrasonic welding, and new machining methods are all being used to advantage.

Conclusion

Certainly many difficult obstacles must be overcome to satisfy the insatiable demands for materials for high-temperature service. Weldability and fabricability of high-strength materials appear to be particularly important problem areas. Less ductile materials than customary are necessarily involved. There will certainly be no materials Utopia—indeed, in some respects, definite limits of materials capabilities are being approached. However, research and development programs now under way on refractory metals, fine-particle strengthening, whiskers, ductile ceramics, composite materials, and fabrication and processing techniques will most certainly lead to major improvements and to the introduction of completely new types of structural materials.

PLASTICS

By Irving Gruntfest[3]

It is now clear that reinforced plastics can be useful in certain types of ultrahigh-temperature service. In spite of the wide interest in these uses, there is still much to be learned before handbook-type data will be available to the engineer.

The properties of plastic materials may be sensitive to the fabrication techniques since the formation and fabrication of plastics are likely to be one and the same process, whereas with metals these may be more or less separable and distinct. As a result, plastics are likely to vary in their properties, even at room temperature.

Another obstacle to obtaining specific design data is the diversity and complexity of high-temperature problems. Certainly the temperature of the environment is not an adequate definition of the service requirements. The energy flux to the part, the time of exposure, and interactions of chemical and mechanical factors also must be taken into account, and materials evaluation cannot be based on tests which simulate only temperature or heat transfer.

Plastics Versus Other Materials

Several hundred different kinds of metal, ceramic, and plastic materials have been exposed to hot-air generators, chemical flames, a solar furnace, and a variety of electric-arc devices at the Aerosciences Laboratory. Thus studies of thermal erosion have been made in gases with widely varying chemistry, temperature, and enthalpy. Some of these observations have been summarized in an earlier article [1].[4] A few more are given here, Table 5. Under very severe conditions of heating, as may be seen in Table 5, the relative durability of plastics may be much greater than that of the usual refractory materials and is exceeded only slightly by that of graphite.

Table 6, from reference [2], shows further that the ranking of a group of materials may be quite sensitive to the test conditions. Among the variables, special attention should be given to the question of the enthalpy or heat content of the gas, Fig. 8. This is the variable which determines the amount of heat which flows from the gas to the test specimen. The erosion of a material in argon at a particular high temperature may, therefore, be quite a bit lower than that of the same material in water or carbon dioxide at the same temperature, even if purely chemical interactions between the material and its environment are ignored. A number of apparent contradictions in test results may be explained when this is taken into account. In Table 6 the erosion rate of the most durable material in a particular exposure is given the value 1. The other materials are then rated according to the ratio of their erosion rates to that of the best.

Table 5 Relative Durability of Materials Exposed to Very Severe Heating in 10-Sec Tests

Material	Relative weight loss in water-stabilized arc (7000 K, 2000 Btu/ft/sec)
Graphite	0.81
Nylon phenolic	1.2
Silicon carbide	1.7–6.3
Refrasil-phenolic	2.2
Glass phenolic	2.2
Silica	2.3
Alumina	6.9–13.7
Mullite	8.22
Zirconia	12.9
Copper	60.0

Table 6 Relative Erosion Rates of Various Materials vs. Temperature of Exposure

Material	Resin, per cent	Temperature, deg C 1800	2500	7000
Phenolic-glass cloth	27	1.0	2.7	2.5
	37	1.2	2.5	2.0
	44	1.6	2.2	2.9
	65	1.7	1.5	1.4
Phenolic-Refrasil cloth	41	1.4	1.0	2.1
Phenolic-nylon cloth	57	4.7	2.5	1.0

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[3] Aerosciences Laboratory, Missile and Space Vehicle Department, General Electric Company, Philadelphia, Pa. Condensed from Paper No. 59—MD-1.

[4] Numbers in brackets designate References at end of paper.

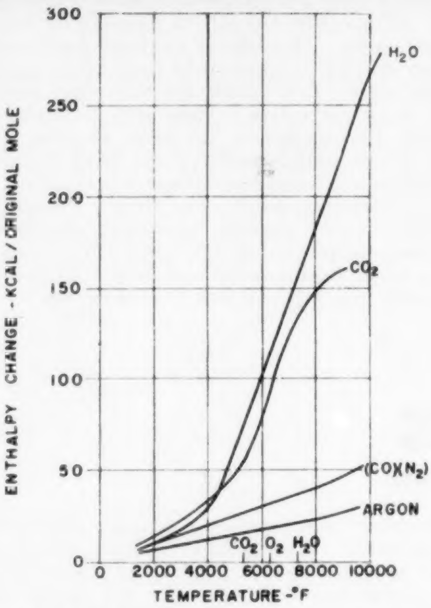

Fig. 8 Enthalpy as a function of temperature for various gases (approximate)

It may be seen that the relative durabilities are reversed in two tests.

In order to understand this rather complicated and perhaps unexpected pattern of results, there should be general consideration of several things that may happen when a material is heated:

Case 1—No damage to material. When a part is exposed to a gas which is not too hot, or has limited capacity to transmit heat to the surface, it is possible to generate an equilibrium situation in which there is no temperature gradient at the surface or the convective heat input is exactly balanced by radiation from the part before damage sets in. A small pin heated in a Bunsen burner is a simple example.

Case 2—Some damage to material. A part is exposed in such a way that the equilibrium temperature is above that at which some damage to the material occurs; for example, above the melting point of the material. Here a transient is first generated, the nature of which depends on the thermal diffusivity of the material and the geometry of the part. Until the surface temperature of the part reaches the melting point no damage occurs. Thereafter, a recession of the surface of the part can be expected. The rate of this process will depend on the heat input, the viscosity of the melt and the shear stress to which it is exposed, and the over-all heat-absorbing capacity of the material including the latent heat of fusion as well as the variables that determined the nature of the transients. A rod of glass heated in a gas-oxygen flame would be an example of this type of behavior.

Case 3—Some vaporization of the material. This case includes that of materials that are not expected to show a liquid phase such as carbon which sublimes at ordinary pressures. Here again a transient will be generated during which no damage occurs followed by an erosion process. For analytical purposes it is useful to distinguish this from case 2 because gas which is generated during the erosion thickens the boundary layer and reduces the effective severity of the heating from the hot gaseous environment. Furthermore, to the extent that the material vaporizes, the latent heat of vaporization must be added to the effective heat-absorbing capacity.

Case 4—Chemical reactions take place. Here there may be a critical surface temperature above which chemical reactions occur at significant rates. Under these conditions the outcome of the experiment will be dependent on the specific chemical situation in the test.

Clearly, it would be remarkable indeed if relative durabilities of materials did not change with service conditions which involve different thermal stabilities, different test times, different energy fluxes, different radiation balances, different thermal diffusivities, different phase changes, and different chemistry. Furthermore, the various hypothetical experiments simulate situations which may arise in engineering practice. This is part of the diversity and complexity of the high-temperature problem referred to earlier.

Behavior of Plastics

As the severity of the service conditions increases, behavior of any one material falls progressively into case 1, 2, 3, and 4, although case 4 may be relevant earlier than 2 or 3. Since plastics as a class begin to decompose at low temperatures (below 1000 F) relative to the so-called refractory materials, the behavior of plastics never falls into case 1 in the regimes of interest in this discussion.

However, since plastics have lower thermal diffusivities than any other materials, the damage that is done, as the case 2 and 3 situations develop, may involve only that part of the material near the heated surface. Thus the mechanical integrity of the part may be relatively unimpaired during a short exposure.

Certain plastics, the thermosetting materials, do not melt in response to heating so that they pass immediately into class 3. Some thermosetting materials decompose or pyrolyze in such a way that they generate large volumes of gas and also produce a porous cokelike residue which may have rather poor thermal conductivity. When such a layer of refractory coke is generated on the surface of a plastic, it can provide some protection to the underlying material. The coke-forming materials do indeed seem to be more suitable for high-temperature service. Of course, in an air environment the gases generated by the heating can react chemically as can indeed the coke residue. Heating experiments conducted on plastics thus are usually covered by case 4.

If, as in the case of the special arc devices or perhaps certain re-entry situations, the environment is extremely hot and can deliver very large amounts of energy to the surface of a material for a protracted period of time, the durability of the material must finally be related to its ability to absorb heat. The heat-absorbing capacity of a material is, of course, merely its integrated specific heat from the initial to the final temperature.

At high temperature, reliable estimates of the specific heat and its integral can be made for any material by more or less standard physical-chemical methods. These integrals have been estimated for various materials and

presented in an earlier article [2]. Organic plastics, in general, can be expected to have higher heat-absorbing capacities than any other structural materials, Table 7.

Comparisons Among Plastics

It has been noted that some plastics are converted to liquids on heating, others are converted to cokelike residues and gaseous products. Different types, for example, polytetrafluorethylene (Teflon) can be gasified without forming either liquid or coke.

In addition to these gross differences in physical behavior, plastics may have a variety of chemical compositions. While the major constituents tend to be carbon and hydrogen, many nitrogen, oxygen, sulfur, chlorine, silicon, phosphorus, and boron-containing materials are in use or being developed.

As a practical matter, homogeneous plastics are not finding application in high-temperature service. Composites containing fibrous reinforcing material are usually chosen. Examples of resins and fillers useful in high-temperature service are shown in Table 8. The amount of reinforcement is frequently about 50 per cent by volume and, allowing for the difference in density, these composites may be only 25 to 35 per cent by weight of the plastic itself. Obviously, the nature and distribution of the reinforcement are relevant to performance. In fact, it has frequently been suggested that in some applications the function of the plastic is merely to hold together small pieces of refractory ceramic which in massive form would not be strong enough or resistant enough to thermal shock to provide a stable structure.

The data given in Table 6 [2] show that this is certainly not always the case. Furthermore, in gas at 1800 C both glass and Refrasil show case 1 behavior and the two types of reinforcement have equal merit. Nylon melts and decomposes, hence it does poorly. At 3000 C only Refrasil shows case 1 behavior, and it enhances the performance of the composite. Here the case 3 behavior of the resin becomes important in the materials containing glass, and the higher the resin content the better the rating. At 7000 C all the substances show case 3 or case 4 behavior. Here the difference between glass and Refrasil is lost again, and furthermore the high gas-producing and energy-absorbing capacity of the organic material is decisive.

Conclusions

The art of the application of plastics in high-temperature service is so young that design work in this area is still quite difficult. What is clear, however, is that for short-time applications some plastics must be considered. Furthermore, at the highest temperatures, at which no materials are stable, plastics may be the most durable substances available.

As to the selection of specific plastics, those on which a coke-like shell develops on heating, such as the phenolics and perhaps certain epoxy resins, seem to be most useful. This result can be rationalized in the following way. The coke is stable at high temperatures; thus the driving gradients at the surface are reduced and back radiation is increased. In addition, if, for example, all the carbon in a hydrocarbon composition is converted to elementary carbon, the other product must be hydrogen. This means that the largest possible volume of low-molecular gas is available for blocking convective heat transfer.

The nature, amount, and distribution of reinforcement also must be considered. Highly refractory fibers of alumina, silica, and magnesia, if available, are likely to be useful in some applications such as occur in combustion gases. In others, where higher temperatures are involved, the presence of inorganic material, however refractory, reduces durability. It is here that materials which are rich in hydrogen and also produce carbon on heating, such as nylon-reinforced phenolic, show the most promise.

As understanding of the over-all problem improves, it is reasonable to expect that plastics will be specially designed which show great improvements in performance.

Table 7 Ultimate Heat-Absorbing and Gas-Generating Capacities at 8540 F for Various Substances

Substance	Heat absorption, Btu per lb	Relative gas volume
H_2 (gas)	120,000	1
(CH_2n) (organic plastic)	43,000	0.21
(CH)n (organic plastic)	36,000	0.15
Graphite	30,000	0.08
Beryllium	17,500	0.11
Magnesia	9,900	0.05
Silica	5,000	0.05
Copper	2,880	0.016

Table 8 Examples of Plastics and Fillers Useful in High-Temperature Service

Resin	Remarks
Silicone	For highest temperature continuous service (700 F) yields SiO_2 residue when severely heated.
Phenolic	For continuous service up to 500 F. Yields carbon residue when severely heated.
Melamine	Yields cokelike residue. Relatively low hydrogen content.
Epoxy	Usual types do not give carbon when heated severely.
Polyester	Same as epoxy.
Nylon	Melts, yields no carbon.
Filler	**Remarks**
Glass	Gives high strength. Can give case 1 behavior.
Refrasil[a]	Gives case 1 behavior under more severe conditions than glass.
Nylon	Rich in hydrogen. Generates large volume of gas when heated.

[a] High silica fiber produced by H. I. Thompson Co.

Acknowledgments

Among the colleagues who have contributed substantially to the general study of thermal erosion (ablation) in the Aerosciences Laboratory of the General Electric Company, on which this paper is based, are: L. R. McCreight, L. H. Shenker, G. W. Sutton, S. Scala, and N. Dow.

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TRANSPORTING MATERIALS IN

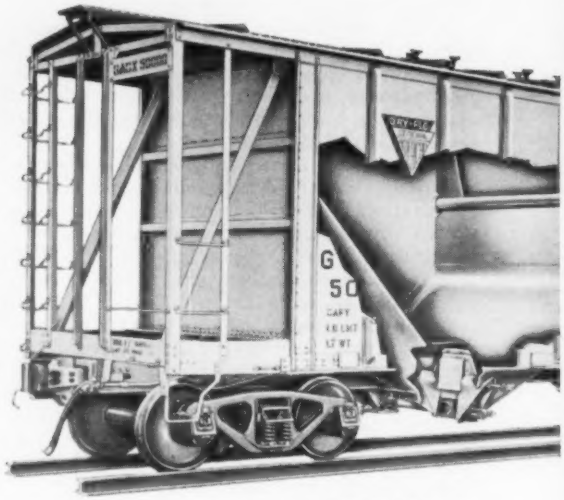
By H. A. Stoess, Jr., Assistant Manager, General Conveying Division, Fuller Company, Catasauqua, Pa.

For both long-haul and short-haul bulk transportation, the railroads' standard rolling stock—or the special cars offered for lease to both producer and user—can handle practically all dry bulk materials.

Why ship in bulk? The answer is mainly economy. Bulk material is not in a package of any sort, and the savings in packaging are reflected in the final cost of the finished product. At present, the differential between bagged and bulk starch is $0.27 per hundred pounds, or $5.40 per ton. A 40-ton car means a saving of $216.

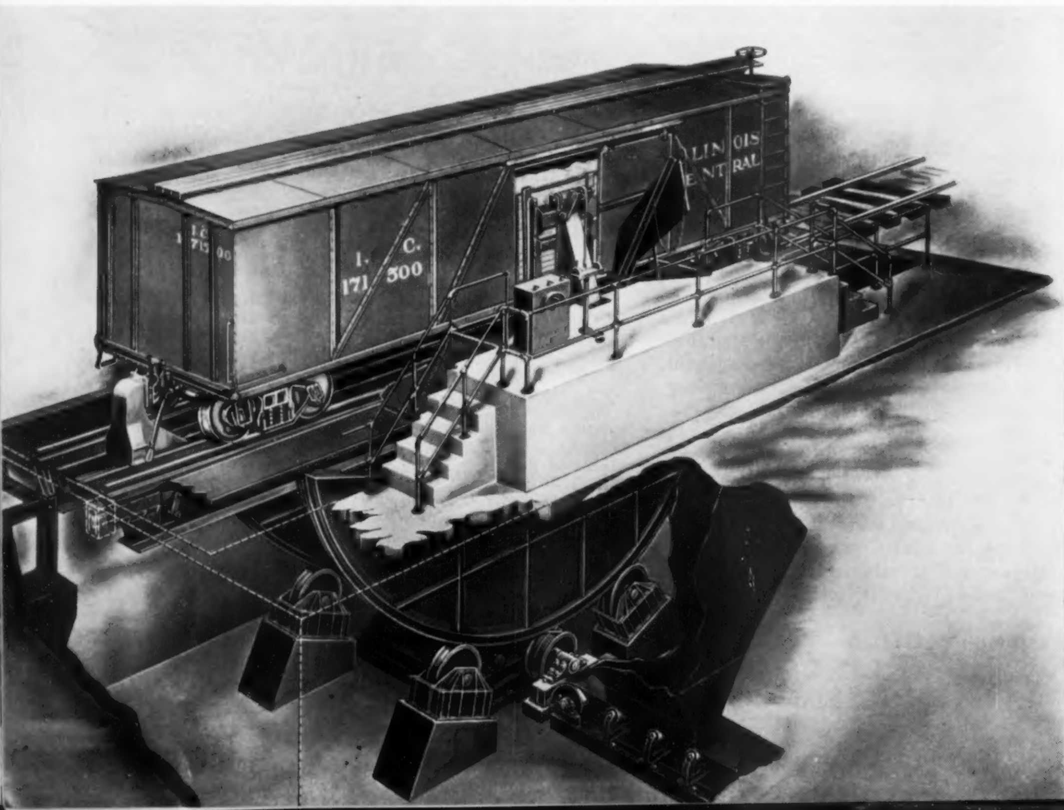
The cars made available by the railroads include the boxcar, the covered-hopper car, and the specialty cars. Specialty cars—among them the "Dry-Flo" and "Kar-Flo" types pictured here—are designed for rapid methods of loading and unloading. Such cars reduce costs not only in handling, but in spillage and contamination. The railroads can provide these cars, or they can be leased from General American Transportation Corporation, Chicago, Ill.

Based on a paper contributed by the Process Industries Division and presented at the Semi-Annual Meeting, St. Louis, Mo., June 14–18, 1959, of The American Society of Mechanical Engineers. ASME Paper No. 59—SA-34.



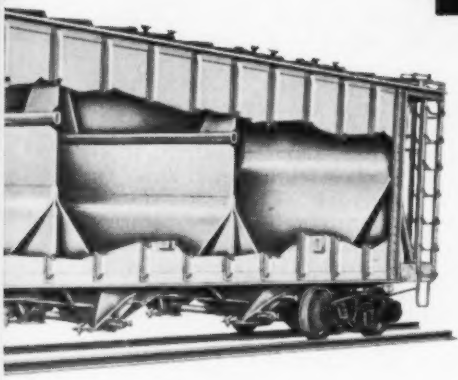
The Dry-Flo car, a refinement of the hopper car, has pneumatic nozzles, **right.** The car is of all-welded construction, all hopper corners having 2½-in. radius, insuring minimum product retention.

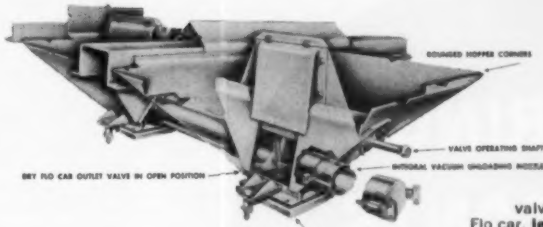
The rotary car dumper. The car tips 15 deg toward the door. The platform tilts 40 deg to empty one end of the car, and then 40 deg in the opposite direction to empty the other end.



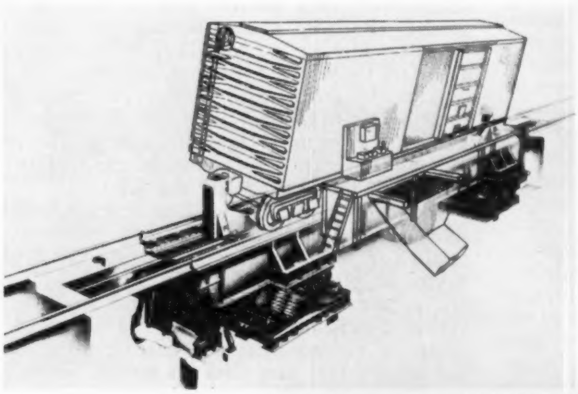
BULK

That old standby, the boxcar, is still used for materials that are lumpy, that will pack in transit, or will not flow. Here, a powered scoop unloads grain, **left**, and an industrial truck, **right**, unloads heavy granular materials.



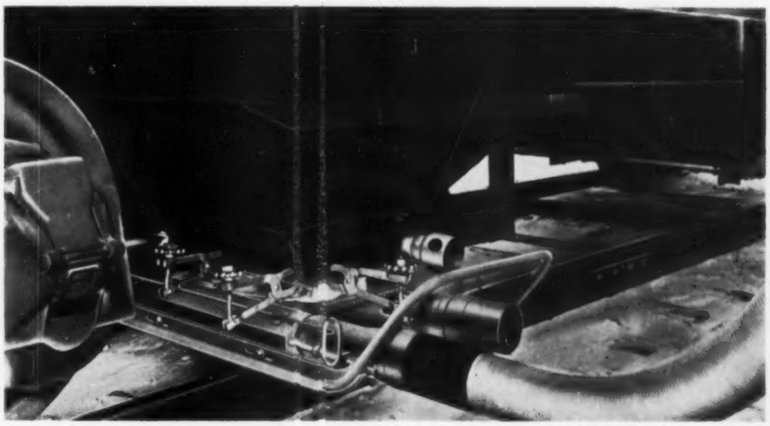


Outlet valve of the Dry-Flo car, **left.** With this pneumatic nozzle, the car can be attached directly to the plant's conveying system.



Requiring less space than the rotary dumper, this Kar-Flo unloader sets up a rocking motion which produces conveying action, moving material from both ends simultaneously toward the center

A pneumatic car-unloading unit used with standard hopper cars. The unit, resting across the rails, connects to the car outlets and to a vacuum-type pneumatic conveyer. These systems can unload all grains and dry materials—pulverized, crushed, and granular—some with particle sizes up to 2 in.



BEARINGS, LUBRICANTS and LUBRICATION

A Digest of 1958 Literature

In the laboratories, lubrication engineers seek answers to higher speeds, higher temperatures, more corrosive environments. Here are the men—and their published papers.

Contributed by the Lubrication Division and presented at the Semi-Annual Meeting, St. Louis, Mo., June 14–18, 1959, of The American Society of Mechanical Engineers. Prepared by Subcommittee B, B. Sternlicht, Chairman.

The "Digest of 1957 Literature" on lubrication appeared in Mechanical Engineering, vol. 80, September, 1958, pp. 64–74.

Fluid Film Bearings

By Richard Elwell[1]

THE 1958 literature on fluid-film bearings has been subdivided into four categories: (*a*) Journal bearings, (*b*) thrust bearings, (*c*) gas-lubricated bearings, (*d*) special topics. For the first time, the increasing interest in gas bearings requires a separate listing of this subject. In addition to the references included, some 25 papers on fluid-film bearings were presented at the Third All-Union Conference on Friction, Wear, and Lubrication of Machines, in Moscow, USSR, April 9-15, 1958. These are listed in *Wear*, vol. 2, August, 1958, pp. 77–80, but the author has been unable to obtain them.

Journal Bearings. Halton [1][2] tests 19 assumptions usually made in the solution of the Reynolds equation. Hays [2] solved the Reynolds equation analytically, and presented design charts. Tao [3] analyzed short journal bearings for the effects of lubricant turbulence on load capacity and attitude angle. Floberg [4] studied an infinitely long bearing analytically and experimentally, giving particular attention to the negative-pressure region. The work was extended by Jakobsson [5] to include a finite-length bearing.

Pinkus [6] analyzed the three-lobe journal bearing for stability characteristics, load capacity, flow, and power loss. Partial bearings were analyzed by Raimondi [7] and Jacobson [8]. Raimondi studied offset loads on a 120-deg bearing, while Jacobson derived the pressure distribution in a partial bearing with an axial oil groove. Railroad journal bearings continued to be of interest. Meeker and McGahey [9] presented performance data for wicking, bearing materials, and oils used in railroad bearings, while Hanson [10] examined factors contributing to failures and means of overcoming them. Keller and Pigman [11] presented a method for predicting running temperature, including the effects of friction heat from both the bearing and the lubricator.

The effects of dynamic loads on bearings were given in three papers. An analytical study by Sternlicht [12] resulted in techniques for calculating the dynamic behavior of plain journal bearings with L/D ratios of $^1/_2$, 1, and $1^1/_2$. An experimental study by Russell [13] of diesel-engine connecting-rod bearings found the effects of various shaft and bearing materials. Hagg and Sankey [14] gave data on partial, tilting-pad, and plain journal bearings under dynamic loads.

Bearing stability, particularly the whirl of lightly loaded plain bearings, was analyzed by Head and Oulton [15] and Halton [16].

Ocvirk and Du Bois [17] presented a method for predicting maximum allowable bearing loads. The results of tests conducted on journal bearings up to 14 in. in diam were presented by Gooch and Whittum [18]. Nelson and Gatcombe [19] gave the results of a study of oscillating journal bearings. Burr [20] presented a method of predicting oil-film temperatures from a heat balance which included heat dissipation by the shaft.

Thrust Bearings. Kunin [21] solved the Reynolds and energy equations simultaneously for pivoted-pad bearings, using an empirical viscosity-temperature relation-

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[2] Numbers in brackets designate References at end of paper.

ship. Hays [22] analyzed finite sliders by separation of the variables in Reynolds equation and predicted load capacity, friction, center of pressure, and flow.

Heat effects were considered by Guilinger and Saibel [23] and Reethof, Goth, and Kord [24]. Guilinger and Saibel analyzed an infinitely wide slider for the effects of heat conductance by the bearing, slider, and lubricant; while Reethof, et al., compared their parallel-plate-bearing theory to experiment.

Milne [25] found a slight increase in load capacity predicted by analysis of the effect of lubricant inertia. Chou and Saibel [26] also found an increase in load capacity, as well as power loss, because of turbulence.

Osterle and Hughes [27] analyzed both gas and liquid-lubricated hydrostatic thrust bearings for the effect of lubricant inertia, while Loeb and Rippel [28] gave methods for optimizing the design of this type of bearing.

Baudry [29] summarized current design practice for very large thrust bearings and compared it to early designs. Brandon and Bahr [30] gave the results of load-capacity tests on large tapered-land and tilting-pad thrust bearings, including a discussion of thermal distortion.

Gas-Lubricated Bearings. Ford, Harris, and Pantall [31] discussed hydrodynamic journal and thrust bearings. A solution of Harrison's equation for infinite-width step thrust bearings was presented by Kochi [32]. Burgdorfer [33] investigated the behavior of gas bearings in rarefied atmospheres, where the length of the molecular mean free path of the gas approaches the film thickness between the sliding parts.

High-speed gas journal bearings were the subject of three investigations. Rieger [34] found by experiment that calculation of power loss by the Petroff equation was sufficiently accurate for most purposes. Osterle and Hughes [35] analyzed the effect of lubricant inertia on journal-bearing pressure distribution. Fischer, Cherubin, and Fuller [36] presented the experimental behavior of a number of gas journal bearings, both hydrodynamic and hydrostatic, to illustrate factors influencing high-speed stability.

Stability of hydrostatic gas-lubricated thrust bearings was the subject of three other papers. Roudebush [37] presented results of an analysis of the equations of motion. Licht [38] also conducted an analysis of the problem, including varying stiffness and damping. Conditions of stability are described. Jay and Peithman [39] described an analytical and experimental study of a type of hydrostatic thrust bearing. An experimental investigation of hydrostatic thrust bearings, with empirical design information, was described by Wunsch [40].

Adams [41] described a unique hydrostatic-hydrodynamic gas bearing, and gave limited design information.

Special Topics. The effect of pressure on viscosity is considered in four papers. The first three were the result of a long-standing project by the ASME Research Committee on Lubrication. The background of the project and existing knowledge on the subject were described by Hartung [42], who also gave plans for further investigation. The effect of pressure on viscosity in thrust bearings was analyzed by Sternlicht [43] and found to raise load capacity and power loss. Needs [44] compared two oils of different viscosity index and viscosity-pressure characteristics for their effects on journal-bearing performance. The oil with low viscosity index was found to cause higher power loss. Tao [45] solved the Reynolds equation for finite-length journal bearings, including the effect of pressure-viscosity variation.

Turbine vibration was attacked by two unique bearing designs in two different applications. Hill [46] described a special floating-pad thrust and journal bearing used in small gas turbines. Schnittger [47] solved a bearing-instability problem in a 10,000-kw gas turbine by an unusual journal bearing, in which the top half was slightly offset from the bottom half.

Bearing damage due to electric-current passage through the oil film was discussed and illustrated in papers by Kaufman and Boyd [48] and Gruber and Hansen [49]. The problem was further investigated by Siripongse, Rogers, and Cameron [50]. Voltage drop across the film was found independent of speed and currents above $^1/_2$ amp.

Fox and Elwell [51] described a radioactive technique for measurement of bearing wear in a sealed refrigeration compressor. Copper-lead bearing material was found superior to babbitt in this instance.

In a wide-ranging paper, Newman [52] described successful lubrication by water of both large low-speed and smaller high-speed bearings. Satisfactory operation of a completely water-lubricated, 4000-hp marine turbine for over 1200 hr was reported. Lubrication by mercury was described by Fischer [53]. Test results were presented for applications emphasizing low friction.

Ball and Roller Bearings

By Paul Lewis[3]

THE literature during the past year fell basically into the following categories: (*a*) Studies of ball motion, (*b*) hydrodynamic aspects of the lubrication of rolling contacts, (*c*) corrosive effects on fatigue of rolling elements, (*d*) high temperature, (*e*) fatigue studies, (*f*) measurements, (*g*) lubrication, (*h*) vibrations and noise, (*i*) special topics.

Studies of Ball Motion. Johnson [54] investigated the motion of a sphere rolling on a plane which, in addition to the rolling motion, spins about an axis normal to the rolling axis. The analysis showed that partial slip and transverse creep occur in the contact area. Johnson [55] also analyzed the case of a rolling sphere on a plane which was a tangential force in the contact area. A creep velocity relative to the plane was defined even though the sphere rolled without sliding. Jones [56] analyzed the ball motion in a high-speed ball bearing by taking into account the inertia forces and interfacial slippage in the contact area. Motion and friction due to slip can be determined from the analysis.

Hydrodynamic Aspects of Rolling Elements. Von Hackewitz [57] modified the analysis of Dörr and Kapitsa for the pressure and film thickness in a roller-bearing con-

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tact. Milne, et al. [58], in observing the grease movement in roller bearings, described a rupture film at the trailing edge of the roller. Dunk and Hall [59] studied the angle of inclination and offset of the resultant force line between rolling disks. Crook [60] studied the hydrodynamic aspects of rollers, finding that the film thickness varies directly with velocity and inversely with load. Crook [61] also investigated the deformation in rolling disks. The experiments showed an undeformed surface layer although a transverse shift at a subsurface level had occurred.

Corrosive Effects of Fatigue on Rolling Elements. Grunberg and Scott [62] have shown that minute quantities of moisture affect the fatigue life. Drying of oils which contained from 0 to 0.033 per cent moisture gave a 10 to 60 per cent increase in the mean life. Moore and Lewis [63] suggested a corrosive action with the use of synthetic lubricants at elevated temperature. The oxidation products become corrosive and have been shown to cause wear in rolling-element bearings.

High Temperature. In the area of high-speed, high-temperature operation, Gray [64] described evaluations using mist, solid lubricants, throwaway systems, and Freon-12. The experimental work ranged to 1000 F.

BEARINGS, LUBRICANTS and LUBRICATION

Morrison, et al. [65], studied rolling-element fatigue to 450 F. The authors found that vacuum melting does not reduce scatter, and the life of the tool steels is reduced at elevated temperature, probably as a result of lubricant deterioration. Sinclair [66] discussed materials and lubricants for instrument bearings for operation above 300 F. Scott [67] found that fatigue life drops with increasing temperature. Bailey, et al. [68], described high-temperature operation using protective atmospheres. Air-hydrocarbon vapors blanketed the system while a polymer formation served to provide lubrication. Ragborg [69] described silicone greases and their effective operating range.

Fatigue Studies. Anderson and Carter [70] demonstrated ball-fatigue results with the effects of fiber orientation, temperature, and dry lubricants. Jackson [71] investigated high-temperature steels, oxidation state of lubricant, and hardness on fatigue life. Carter and Anderson [72] found that fatigue life is increased with increasing lubricant viscosity. Baughman [73] showed a fatigue dependence on lubricant viscosity. An attempt was made to correlate bearing fatigue life with that obtained in the single-element rig.

Measurements. In the area of basic measurements, Drutowski [74] determined the rolling force of a ball between parallel plates. Elastic hysteresis accounted for most of the loss and the material damping capacity was defined. El-Sisi [75] measured the film thickness between rotating disks by current conduction through the film. MacConachie and Cameron [76] utilized the voltage-discharge characteristics of the lubricant to determine film thickness. A constant current was passed through the film and discharge voltage was measured. Emmerich [77] described methods for determining the preload of ball and roller bearings. Combe [78] described the use of radioactive techniques to determine ball-bearing wear. Kuhlenkamp and Staroste [79] and Asch [80] described testers for ball-bearing-torque determination. Mura and Yoshimoto [81] measured quenching stresses in a bearing ring by interference fringes. The method employed an interferometric technique to detect ring deflections.

Lubrication. Murteza [82] studied oil-jet lubricating techniques and demonstrated the effects on bearing temperature and torque. Best results were obtained by opposing the direction of the jets to the direction of thrust load on the inner ring. Rounds [83, 84] gave criteria for lubricant and systems choice for ball-bearing operation. Accinelli, et al. [85], gave information on the lubrication of high-speed thrust ball bearings. The ball to race slippage was used to simulate contact temperatures and assess the frictional damage characteristics. O'Halloran's [86] experimental results showed that grease flow occurs in shielded bearings. Irwin [87] set forth a guide for lubricants for instrument ball bearings.

Vibrations and Noise. Tallian and Gustafsson [88] investigated vibrations of rolling-element bearings. Surface imperfections were analytically treated by Fourier analysis and the bearing was treated as a coupled system. Downes [89] discussed noise reduction by the use of rubber mountings on the bearing outer race.

Special Topics. Martin and Jacobs [90] discussed the factors affecting the operation of ball bearings in liquified gases. Montalbano [91] described the properties and applicability of plastics for rolling-element bearings. Ortman and Green [92] analyzed the requirements for isoelastic conditions in ball-bearing-mounted gyro applications. Contact angle appears to be the major factor. Barish, et al. [93], Johnson [94], and Bakewell [95] discussed the bearing problems associated with aircraft electrical accessory equipment.

Friction and Wear

By W. W. Shugarts, Jr.[4]

Ling and Saibel [96] studied the role of recrystallization welding in the rubbing of dry metallic surfaces. A derivation based on thermal considerations was shown to compare favorably with experience. The same authors [97], following the work of Levitskii (M. P. Levitskii, *Doklady Akad. Nauk SSSR*, vol. 92, 1953), applied the concept of a unimolecular reaction to a more realistic model of the friction process. The results showing the dependence of the coefficient of friction on various parameters appear to follow qualitatively the experimental results of others. Courtney-Pratt and Eisner [98] investigated the relative tangential move-

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ments of two bodies and the size of the area of contact between them when first loaded normally against each other and then subjected to tangential forces too small to cause sliding. Quantitative data were obtained on microdisplacements before sliding. Rabinowicz [99] described a mechanism of loose-particle formation in which the particle's elastic energy exceeded the surface energy at the point of attachment. The concept of a critical size of particle was supported by experiments up to 400 C with zinc on zinc.

In a friction-measuring apparatus designed to simulate bearing performance Twiss, Willson, and Sydor [100] tested (*a*) polytetrafluoroethylene reinforced with additives and (*b*) molded products of phenolic resins, PTFE, and fillers. The coefficient of friction was shown to be inversely related to the amount of PTFE present. The results of a few bearing tests were included. Vagramyan [101] described the use of the thermoelectric voltage arising between dissimilar metals for measuring interfacial temperatures developed when metals slide over one another. Results were shown for tests of bronze and steel. Barwell [102] discussed the mechanism of wear and the variety of factors affecting its nature and magnitude. Illustrations of conditions prevailing in engineering applications included pitting arising from rolling contact, scuffing arising from sliding contact, fretting corrosion due to vibratory motion, and the effect of oxygen on friction and surface damage during simple sliding. He concluded that metallurgical structure may have a great effect in determining the wear resistance of materials.

Several authors studied wear in combustion engines. Malschaert [103] surveyed chemical and spectrographic methods of determining the metallic content of lubricating oils as a measure of wear. Pontious [104] discussed conventional physical and radioactive laboratory methods used in determining wear. He demonstrated their applicability to specific wear problems of piston ring, piston pin, and valve-train wear under various operational conditions. Three papers dealt with the use of the radioactive-tracer technique to study engine wear. Agius and Pegg [105] used a radioactive cylinder liner. They measured the radioactivity in the oil during a road-test program and were able to show appreciable differences in wear rates for different lubricating oils and different diesel fuels. Thiery [106] and Abowd [107] used radioactive tracers to study piston-ring wear. Abowd developed a technique to permit separate simultaneous recording of wear on the face and the side of the ring. Gambill [108] evaluated the lubricity of oils in a refrigeration compressor by similar radioactive techniques.

Kingsbury [109] developed an expression and obtained experimental confirmation relating the friction coefficient in a boundary-lubricated sliding system to temperature, heat of adsorption, and sliding velocity. A simple method for measuring heat of adsorption as a function of temperature was also produced. Deryaguin, Karassev, et al. [110], demonstrated the dependence of viscosity on the distance from a solid surface and the effect that it can have in the mechanism of boundary lubrication. They also discussed a two-term law of friction and compared it to the single-term law of Bowden and his school. Birchall and Moore [111, 112] reported on investigations to provide data for the design of machine-tool slideways. They showed the effect of the type of surface, lubricant viscosity, and load on friction, stick-slip, and the onset of full fluid-film lubrication. Goodzeit [113] reviewed the basic considerations in selecting journal-bearing metals with special reference to antiseizure properties. Coffin [114] tested a variety of materials as a thrust bearing using NaK, xylene, and spindle oil as lubricants. The results showed that bearing clearances in the micron range and a corresponding high load-carrying capacity were possible following an extreme wear-in procedure. Langdon [115] discussed the theories relating to sliding resistance and studied the effects of material combinations, surface finish, surface contamination, lubricants, and hardness on sliding friction.

Campbell and Harriden [116] investigated the effects of sliding velocity and surface roughness on friction and metal transfer using radioactive copper. Milne [117] reported that the adhesion theory of friction originally suggested for metals appears to be applicable to the frictional behavior of a soft solid such as grease. He suggested that the results have implications for an understanding of time-dependent effects in the friction of other materials. Dunk and Hall [118] presented an analysis and the results of experiments made to determine the nature of the frictional resistance between two disks in peripheral contact. Colwell [119] observed and measured the behavior of lubricants at continuously varying load conditions in the presence of accelerated wear and a substantial change in the geometry of the rubbing surfaces during a single test. An oil-well turbodrill thrust bearing was studied in the laboratory by Kol'chenko and Silin [120] to reduce the abrasive wear caused by the circulation of hot water and mud. Tabor [121], in a study of friction, lubrication, and wear of synthetic fibers, found that the frictional behavior depends both on the load and the shape of the surfaces. This was explained in terms of the adhesion theory of friction. Using reflection electron microscopy, he studied surface damage resulting from the rubbing of polymeric materials. Experiments on the boundary lubrication of polymers indicated that boundary lubricants were less effective on polymers than on metals. Also, an account was given of work on the friction of yarns over cylindrical guides showing the importance of hydrodynamic factors and the role of the viscosity of the lubricant or finishing agent employed. Rabinowicz [122] reviewed the effects of galling, poor oil, dust, and surface cracks on the useful life of mechanisms. Simple equations and curves were given for estimating both adhesive wear and abrasive wear, and examples of applications to design problems were included.

Allan and Chapman [123] presented design data on the coefficient of friction of polytetrafluoroethylene (du Pont's Teflon). The variation of the coefficient with load, speed, and temperature was discussed in terms of current friction theory. Swikert and Johnson [124] reported on an experimental study of the wear of carbon-type seal materials. Bodies molded with high-graphite-content materials and made hard by improved methods gave more acceptable friction and wear results than carbon made graphitic by electrographitization. The wear of typical carbon was only slightly affected by variations in hardness of a hardenable stainless steel and, within a limited range, variations in the roughness of ground surfaces of Type 347 stainless steel were not important to the wear of carbons. Seal [125] worked on solid-film lubrication with emphasis on the influence of gaseous adsorption and temperature. He also discussed the friction and wear of diamonds. Coffin [126] studied the behavior of synthetic sapphire sliding against fairly

pure metals as a function of temperature. High friction and metal transfer occurred with the sapphire-nickel combination unless oxygen was excluded, while sapphire-gold exhibited low friction and metal transfer regardless of the atmosphere and temperature. Apparently resistance to oxide formation is an important criterion for good sliding characteristics. Tamai [127] also studied oxide films but with particular reference to their effect on electrical-contact resistance in a repetitive reciprocating sliding system. He found that the nature of the oxide film, that is, thickness, hardness, or crystalline state, influences the characteristics of contact resistance.

Four authors studied surfaces. Trillat [128] used the electron-diffraction technique and discussed the microgeometric and physicochemical aspects involved. Godfrey [129] pointed out the applicability of the electron-diffraction technique to the field of lubrication research. He covered the theory of diffraction by crystals, specimen

BEARINGS, LUBRICANTS and LUBRICATION

preparation, and pattern interpretation and gave examples of diffraction patterns from friction surfaces. Grunberg [130] reviewed the phenomenon of the emission of exo-electrons from metal surfaces. He suggested that the emission centers are associated with nonmetallic, that is, oxidic, surface layers and that such layers may have considerable depth. A general review of surface-examination techniques was made by Barwell [131]. He compared the relative merits of various methods of surface and subsurface examination as to their usefulness in studying changes in topography, chemical nature, or physical structure, with a broad and welcome view of this subject.

Shotter and Tagg [132] studied the friction and wear of pivot bearings for meters. Friction-life curves show initial increase, flattening out, and then final rise, before the increase has reached a limiting value. Feng and Rightmire [133] demonstrated a technique for visual examination of the progressive development of fretting. Experiments were made in three different atmospheres—dry air, carbon dioxide, and helium. They concluded that a chemical reaction such as the oxidation of a metal with the environment takes place when the metal is being, or has been, removed from a surface. Wellinger and Uetz [134] discussed the abrasive effects of granulated materials under conditions of dry or wet sliding, suspension in a liquid, and blasting. The abrasive resistance of various materials, for example, steel, white cast iron, smelt basalt, sintered corundum, and rubber, were considered.

The Conference on Lubrication and Wear held by The Institution of Mechanical Engineers in London, October, 1957, received the well-deserved attention of a number of authors and publications.[5] The *Engineer* [135] dealt with the high lights, and *Scientific Lubrication* [136] devoted an entire extra issue to condensed versions of all the papers presented. Bowden [137] reviewed the papers on "The Friction of Solids"; Barwell [138] reported on the papers on "Wear," and Davies [139] discussed the papers on "Boundary Lubrication."

[5] Complete proceedings of the conference are available from ASME.

Automotive Lubricants

By J. Cunningham[6]

The 1958 literature relating to automotive lubricants included many aspects of lubricating oils such as the characteristic requirements and performance of their use in varied equipment from large marine diesel engines, railway-traction diesel engines, heavy-duty and light trucks, passenger cars, and outboard motors to lawn mowers.

General. Design and performance trends in passenger cars according to Johnson and Mortensen [140] have increased the severity of crankcase motor-oil problems with reference to blow-by, bearing loads, and valve trains. Transmission-fluid requirements, trends in rear-axle lubricants, chassis components, and accessories, were included. Similar information was extensively reviewed in *Lubrication* [141].

Noll [142] in efforts to improve rear-axle lubricants concluded from analysis of used GL-4 lubricants that the chemical balance of additives was disturbed after a short period of use.

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Cox and Hobson [143] emphasized problems in lubrication of large low-speed diesel engines when operated on low-quality and residual fuels, and discussed development of a highly basic emulsion-type lubricant.

Requirements of the lubricating oil and development of a new cylinder lubricant for large low-speed marine diesel engines were outlined in *Lubrication* [144].

Conover [145] discussed qualifications of outboard-motor oil and indicated the need for its improvement. Requirements were outlined in [146].

Current requirements and specifications of automotive-diesel-engine oils with reference to military specifications Mil-L-2104A, Mil-L-9000D, and Caterpillar Tractor Company's series 2 and 3 were reviewed by Johnson and Lowther [147]. The performance of lubricants, and the role of base stock and chemical additives in handling contaminants and debris which may cause deposits and wear were included.

Godfrey [148] reviewed translations of a number of recent Russian papers on lubrication and wear. Those on automotive lubricants investigated the nature of the

action between lubricant additives and metals with labeled atoms. Antiwear properties of lubricants were studied by means of a 4-ball machine and by radioactive techniques, and metal corrosion by lubricant using labeled atoms.

Beck [149] summarized lubrication problems of internal-combustion engines required to operate below −35 F and a development program for suitable lubricants.

Deposits and Sludge. A report on engine deposits in fleet tests by Schwarz and Cline [150] indicated that a lubricant-additive combination which functions at high temperatures does not necessarily prevent low-temperature sludge.

Kalinowski, LaCroix, and Nejdl [151] gave the proportionate effects of the base oil, viscosity-index improver, detergents, and inhibitors in an automotive lubricant upon the formation of combustion-chamber deposits.

Musselman and Albrecht [152] studied engine sludge as affected by oil composition in fleet tests. The authors concluded that the fuel, driving conditions, and the engine conditions were the most important criteria of sludge formation.

Agius and Mulvey [153] studied sludge suspension in engine oils containing detergent additives.

Additives. Every forward step in the development of the passenger-car engine has increased the need for multipurpose additives in the lubricating oil. Larson [154] described research on the additive mechanism of zinc dialkyl dithiophosphates as antioxidants, bearing-corrosion inhibitors, antiwear, and extreme-pressure agents. Scanley and Larson [155] investigated zinc dithiophosphates as lubricating-oil additives and their effect on solubility, thermal stability, antioxidant, and antiwear performance. Laboratory and engine results were in agreement. Dodgson [156] described the nature of such chemical additives in engine lubricants as antioxidants, corrosion inhibitors, detergents, rust inhibitors, viscosity-index improvers, and pour-point depressants.

Bennett [157] made an interference-microscope study of the action of oil additives on metal surfaces. It was found that engine oils containing zinc dithiophosphate additives could increase the small-scale roughness of the lifter-foot surface of the valve-train mechanism. Willis and Ballard [158] studied detergent additives with reference to crankcase filter performance. Ashless detergent was found most effective in minimizing filter plugging. Twiss, Loeser, and Wiquest [159] discussed the action of zinc dialkyl (C_6) dithiophosphate as an antiwear additive in preventing scuffing of automotive-valve-train components. A bench-scale cam-and-tappet test machine with instrumentation of proficorder radiotracers, densitometer traces, electron and light-microscopy were used to measure magnitude of observed effects.

Multigrade Lubricants. Components in the formulation of multigrade lubricants for both light and heavy-duty service were discussed by Test and Greeger [160]. Their use resulted in easy starting in cold weather, low oil consumption, reduced octane requirements, and reduced fuel consumption (assuming stop-and-go cold-weather operation). Advantages for fleet operation were one oil for all locations and all seasons, and lower inventory.

Colyer and Muller [161] made field tests of six types of equipment in 3 million miles of heavy-duty service. Engine wear and oil consumption with multigrade lubricants were equal or lower than with single-grade oils in similar service. Fuel economy and faster cold-weather starting outweighed the additional cost.

Wear. Furey and Kunc [162] reported on the use of radioactive valve lifters in a study of valve-train wear. Tests also used zinc dialkyl dithiophosphate containing radioactive Zn-65. They concluded that wear-controlling ability of this additive does not depend upon the presence of zinc.

Bätzold, Clarke, and Kunc [163] investigated piston-ring wear in a passenger car during stop-and-go operation with a radioactive-tracer technique. Start-up wear was about four times that of highway operation.

Agius and Pegg [164] used a radioactive liner to study engine wear. Pontious [165] discussed conventional physical and radioactive laboratory methods in an investigation of engine-wear problems affecting lubricant development. Groff [166] gave a résumé of research and tests by Ford Motor Company, Lubrizol Corporation, SAE, and others on the effect of composition of lubricating oils on gasoline-engine wear by corrosion, abrasion, and erosion.

Lubrizol International [167] reported that engine wear was considerably reduced by the use of oils treated to Supplement-1 level, over that with straight oil, when operated under sludge-forming conditions of cold starting and running. Data were obtained from extensive field tests on popular British passenger cars.

Clark [168] indicated the effects of sulfur compounds on corrosive and abrasive wear in cylinder lubrication of marine diesel engines, and discussed practical methods of reducing wear in residual-fuel operation. Habermann [169] reported laboratory and ship tests using an emulsion-type oil with additives soluble in the base-stock oil. The life of cylinder liners when burning boiler fuel could be increased to the level obtained with diesel fuel. Boyden [170] determined that reduced cylinder-liner wear and substantially lower maintenance costs were obtained when using an emulsion-type oil in trial runs of two vessels.

Kessler and Koenig [171] discussed the action of lead-coated pistons upon the lubricating oils of internal-combustion engines. Detrimental catalytic action of lead was not equal in all engines. Greatest action occurred in supercharged 2-stroke diesel engines. Action in 4-stroke diesel engines was almost nil. In gasoline engines the reaction temperatures were lower, and the action from lead on pistons was insignificant in comparison with that of lead introduced by fuels.

Sennstrom [172] indicated that abrasion by foreign particles from combustion air and other sources was the principal cause of wear, in reporting for a panel on locomotive-diesel-engine maintenance.

Kalb and Pier [173], using special nonemulsion oils formulated specifically for lubricating pistons and cylinders of large marine and stationary diesel engines when burning low-quality fuels, reported cylinder-wear reductions from 37 to 80 per cent less than obtained with a heavy-duty oil.

Oil and Engine Tests. In an investigation of laboratory diesel-engine tests as a means for qualifying a lubricating oil for gasoline-engine service, Patterson and Waddey [174] concluded that superiority of oils in diesel-engine tests does not necessarily indicate a superior lubricant in a gasoline engine. Caterpillar-engine tests failed to predict field-test performance in gasoline engines. Oils that were satisfactory in fleet service with gasoline-

engine vehicles gave wide variations in laboratory diesel-engine tests.

Miller, Hartmann, and Tantet [175] correlated data from 6 million miles of field tests and 800 FL-2 tests, and concluded that FL-2 and lead-paint tests provide a means for evaluating performance of gasoline-engine lubricating oil. The availability of improved additives, in conjunction with laboratory tests, permitted formulation of lubricating-oil requirements. Field tests on a gasoline-engine vehicle, which had a molybdenum disulfide compound in the lubricating oil was operated under oil-starved conditions, and also without any oil were reported in an article [176].

Coon and Loeffler [177] traced the routes of crankcase-oil loss from an engine and determined that $^1/_3$ to $^2/_3$ of the oil consumed was lost by way of the valve assembly. Viscosity and volatility of the lubricant were important factors. A reduction of $^1/_3$ in the oil consumption was obtained in changing from SAE 10 to SAE 30 lubricant.

The low-temperature behavior of motor lubricating oils was investigated by Selby [178] and by Foehr and Furby [179]. Selby studied the dependency of engine cranking speed upon the viscosity of the lubricating oil from +3 F to −35 F. Foehr and Furby used winter field studies of pour reversion to determine the stable pour points of engine lubricating oils.

Spectograph and other physical and chemical tests on samples of crankcase oil yield information on the operating condition of the Pennsylvania Railroad's diesel engines [180], saving $500,000 annually in cost of replacement parts and oil changes.

McCoy [181] considered engine construction as related to oil filtration, oil contamination, and deterioration for large marine and stationary engines.

Analysis. Bernelin [182] presented a photometric analytical method for quantitative determination of the carbonaceous material in used lubricating oil from diesel-engine crankcases. Equipment used in spectrographic analysis of lubricants of railway diesel locomotives in Britain was described in [184].

Schilling, Bernelin, and Fosse [185] proposed methods for rapid determination of the extent to which detergent oils deteriorate while in use.

Miscellaneous. Authors of [186, 187, 188, and 189] presented phases of the manufacture, packaging, and marketing of lubricating oils. Authors of [190, 191, 192, and 193] described new research and test facilities for the continued improvement and developments of automotive lubricants.

Metalworking Lubrication

By M. C. Shaw[7]

As USUAL, the greatest activity in the field of metalworking lubricants was concerned with cutting fluids. Several tests were proposed for evaluating cutting fluids. Husa and Bulkley [194] based theirs on tool wear, surface finish, and tool temperatures. Hartung, Johnson, and Smith's [195] threading test for cutting fluids was based on the measurement of tapping torque. Colwell and Branders [196] discussed reaming-test results with different cutting fluids. Colwell [197] described a friction and wear machine believed to yield data concerned with cutting-fluid performance. Sudholz [198] reviewed possible methods of evaluating cutting fluids. Daasch, et al. [199], described accelerated radioactive-tool tests for use in evaluating the effectiveness of cutting fluids.

BEARINGS, LUBRICANTS and LUBRICATION

Several papers were concerned with the selection and application of cutting fluids. Zylstra [200] discussed the types of fluids available, while Niedzwiedski [201] considered criteria for selection. Fluids for nonferrous alloys were considered [202] and some Russian data were given on cutting-fluid performance [203]. Hoar [204] discussed nitrite corrosion inhibitors for various types of lubricants including water-base cutting fluids. Increased tool life resulted from spraying cutting fluids according to Wilcox [205], and Russian use of a high-pressure stream of coolant was described for a Russian manufacturing plant in [206].

Cleaning and reconditioning of used cutting oils were discussed by Myler [207] and Lipton and McKibben [208]. The cleaning of grinding fluids was similarly discussed by Wilson [209].

Dyer [210] dealt with the importance of coolants in belt grinding. The possibility of maintaining a more uniform temperature throughout the day's production by heating the coolant was suggested for precision-grinding operations in [211]. The special importance of the fluid when grinding titanium alloys is discussed by Foote [212].

Lubricants for wire-drawing operations were considered by Dahl and Lueg [213], while extrusion lubricants were described by Gardner [214]. Deep-drawing results with liquid and solid lubricants were presented by Coupland and Wilson [215] for both ferrous and nonferrous metals. The use of glass compositions in hot pressing, stamping, rolling, drawing, and extrusion in the USSR was described in a paper by Kovalev and Ryabov [216].

German use of rolling oils and emulsions in the cold rolling of steel was treated in the papers by Lueg, Funke, and Dahl [217] and Billigmann and Fichtl [218]. Lubrication studies on rolling oils for copper alloys were also presented by Reynolds [219].

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Lubricant Properties

By Albert A. Schwartz[8]

Additives. The nature and properties of the various antioxidants, corrosion and rust inhibitors, detergents, pour-point depressants, viscosity-index improvers, and extreme-pressure additives used as additives for combustion-engine lubricants, hypoid-gear lubricants, and industrial lubricants were reviewed by Dodgson [220].

Davey and Edwards [221] investigated the extreme-pressure properties of a number of monosulfides and disulfides in mineral oil by means of the four-ball tester. The results indicated that the disulfides are superior to the corresponding monosulfides, but that the nature of the groups attached to the sulfur atoms has a marked effect on performance. This suggests that a definite relationship exists between chemical structure and extreme-pressure activity. A method for determining the activity of sulfur-containing additives, based on the quantitative measurement of the corrosiveness of the additive toward copper, was developed by Sellei [222].

The mode of action of chemically reactive additives was investigated by Loeser and Twiss [223], using extreme-pressure additives containing radioactive isotopes. They found additive activity to be a function of concentration, temperature, pressure, nature of the wear surface, and presence of other reactive oil additives.

The preparation of lubricating-oil additives was investigated by Fields [224] and by Fisch, Messina, and Gisser [225]. Fields synthesized a series of corrosion inhibitors for copper-lead bearings and silver. Fisch, et al., prepared rust inhibitors suitable for use in instrument lubricants.

Analysis, Testing, and Evaluation. Various instrumental methods of analysis and their application in the determination of the characteristics of petroleum products were reviewed [226], including absorption, emission, mass-spectroscopic, and x-ray techniques. Bertolacini [227] reported on the development of an extraction-titration method for the determination, either singly or in combination, of barium, calcium, and zinc in lubricating-oil additives and blended oils.

A method for determining the chemical constitution of higher "naphthenic acids" present in lubricating oils was developed by Knotnerus [228]. He suggests the name "petroleum acids" instead of naphthenic acids in view of the fact that the acids were found to be derivatives of other compounds in addition to naphthenes.

Many new or revised standards for the testing of petroleum products and lubricants were issued by ASTM [229].

Schrock and Starkman [230] designed and developed a thin-film spherical conduction apparatus for measuring the thermal conductivity of liquids, particularly viscous liquids such as hydrocarbon lubricants, with an accuracy of about 2 per cent.

Rawson [231] described a simplified method for testing the shear stability of lubricating oils, involving the use of a fuel injector apparatus, and applied it to the investigation of the effect of shear on viscosity-index improvers. Comparative data from bench and field tests were presented.

Scott [232] modified the rolling four-ball test rig for use at elevated temperatures and applied it to the evaluation of solid and silicone-type lubricants at 200 C. The four-ball E.P. tester was utilized by Paleari, Girelli, and Siniramed [233] to evaluate the antiseizing and recovery from seizure properties of E.P. oils.

Improved correlation between laboratory studies of the coking tendencies of oils in the panel coking test and actual service experience in jet and other engines was sought by Rounds [234]. Results indicated that better correlation might be obtained by certain changes in the test conditions.

The voltage-current characteristics of thin oil films were investigated by Siripongse, Rogers, and Cameron [235]. They found that for normal oils the voltage drop across the film is independent of current above about $^1/_2$ amp and that this value is independent of viscosity of oil and speed of moving surfaces but is sensitive to amount of impurity in the oil.

Greases. Ingold and Puddington [236] measured the densities at 25 to 320 C of anhydrous lithium and sodium soaps prepared from acids produced by the oxidation of paraffin wax. They found only minor discontinuities in the density-temperature relationship as compared to those exhibited by the corresponding stearates. This was attributed to the complex nature of the soaps and accounts for their excellence as grease thickeners.

A review of the fundamentals of lubricants flow was presented by Connors [237]. He also described an experimental automatic-worker-type viscometer for the investigation of the effects of temperature, shear rate, shear stress, and amount of working on grease consistency.

O'Halloran, Kolfenback, and Leland [238] described a dye-tracer technique for measuring the relative flow of the soap and oil components of greases in shielded bearings. Application to small high-speed bearings showed a substantial movement of the grease as an entity between the bearing and shields.

The behavior of a mixed soap grease under cyclic shear stresses resulting in cyclic deformation was reported by Forster and Kolfenbach [239], who deduced the distribution of relaxation times as a function of frequency. Evidence of three different types of relaxation mechanisms was obtained.

Equations for calculating the flow of lubricating greases were developed by Criddle [240] and by Sisko [241]. Criddle presented data on measured and calculated flow rates for a number of different types of greases to demonstrate the validity of the equation. Sisko was able to fit the equation to experimental flow data for other viscoelastic materials as well as greases.

Criddle and Cortes [242] investigated the effect of tensive and compressive forces on the bleeding of a large number of greases. It was found that in every case the application of tensive stresses reduced bleeding and compressive forces increased bleeding.

The various parameters affecting grease bleeding were studied by Calhoun [243]. Soap-type and concentration, oil viscosity, pressure, temperature, fiber size, structure and dispersion, thickness of the grease layer, and fineness of the supporting screen were all found to affect bleeding. Indications were, however, that some unknown factor possibly involving the micelle structure of the thickener exerts major influence in bleeding.

The various test methods for the evaluation of oil

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separation from greases were reviewed by Ellis [244]. The influence of bleeding on specific applications was also discussed.

The mechanical evaluation of greases and the equipment used were discussed by Harris [245] and Barnett [246]. Particular emphasis was placed on the evaluation of greases for high-temperature, high-speed applications.

The results of high-temperature pumpability tests and gel strengths of various greases were summarized by Magie [247]. An attempt to correlate the flow properties of greases with the losses in pressure lubricating systems was made by Koenig, Johnson, and Baniak [248]. The method was applied to the prediction of such losses.

Bernelin [249] reviewed the use of optical microscopy in the control and examination of greases and discussed results obtained with greases both in the course of manufacturing and in actual service.

Tourret and Baker [250] investigated the repeatability of leakage tests with the ASTM Wheel Bearing Test Rig and the compatibility of several grease mixtures.

The properties and performance characteristics of several new greases were described [251], [252], and [253].

Radiation Studies. A number of investigators studied the effects of radiation on various organic fluids and lubricants. Rice [254] investigated the resistance of petroleum oils, diester lubricants, polymer-thickened silicate-ester hydraulic fluids, and so forth, to gamma radiation, using changes in viscosity, evaporation rate, and gas evolution as criteria. The susceptibility of various lubricants to radiolytic attack was studied by Bolt and Carroll [255], who found that oxidation was greatly accelerated by radiation but that various additives, particularly certain selenium and iodine compounds, were effective in reducing radiation damage. The damage is dependent on total radiation dosage and independent of radiation intensity. Representative turbine oils and turbine-oil components were exposed to electron radiation and evaluated for radiation-induced changes in their functional characteristics by Kottcamp, Nejak, and Kern [256]. The effects of pile radiation (neutrons and gamma rays) on lubricants were studied by Irving [257]. The relationship between neutron dosage and viscosity increase, and aromatic content and viscosity increase were reported and the radiation stabilities of silicone and hydrocarbon oils compared. Manley, Pukkila, and Barry [258] utilized a Van de Graaf accelerater, Co-60, and a reactor to investigate the effects of different types of radiation on lubricating oils. Static and dynamic radiation testing indicated that the latter is more realistic for actual performance evaluation of lubricants although the former is suitable for screening purposes.

BEARINGS, LUBRICANTS and LUBRICATION

The development of lubricants suitable for application in radiation environments was undertaken by several investigators. Handschy, Armstrong, and Gordon [259] reported on the development of a tester for the evaluation of greases under simultaneous irradiation, oxidation, and mechanical working. Evaluation of greases and grease components was carried out to determine the oils and thickeners showing the greatest resistance to radiation degradation. Carroll and Bolt [260] investigated the radiation stabilities of various fluids, polymers, and inhibitors and used this work as a basis for the formulation of radiation-resistant oils.

Problems encountered in the nuclear application of petroleum lubricating oils and the lubrication requirements were reviewed by Nailer [261]. The problems involved in testing lubricants under dynamic conditions in a radiation environment were reported by Clark and Lawrason [262].

Rheology. A single viscosity system for the classification of all industrial lubricants regardless of application was proposed by Jordan [263] and compared with existing systems.

A "Slope-Index" system for expressing the viscosity-temperature characteristics applicable to all liquids and lubricants was proposed by Klaus, Hersh, and Pohorilla [264] to overcome the disadvantages of the viscosity-index method.

Miller, Walsh, and Slaymaker [265] found changes in apparent viscosity in all of seven greases tested for changes in capillary-length-to-diam ratios up to 250:1. Beyond this point little change was noted except for one grease which exhibited change to ratios of 1000:1.

The flow properties of lubricating oils under pressure were studied by Hahn, et al. [266]. By assuming a transition from Newtonian to non-Newtonian flow at high pressures and an increase in relaxation time with increasing pressures, and by introducing these concepts into the Ree-Eyring theory of non-Newtonian flow, a new flow equation was derived which was successfully applied to a variety of petroleum and nonpetroleum lubricants. Very close agreement between theoretical and experimental flow data was obtained.

Solid Lubricants. Research information on solid lubricants was compiled by Johnson [267]. The theory of solid-film lubrication was reviewed and the possible applications considered.

Some of the variables affecting the performance of dry-film lubricants were reported by Berry [268]. The falex tester was used as an evaluatory tool.

Kay and Tingle [269] deposited thin films of polytetrafluoroethylene on metal substrates and investigated the lubricating properties. Tenacious films of low frictional characteristics and high load-carrying capacity were prepared.

Stupp [270] studied methods for utilizing molybdenum disulfide and compared that material with graphite and boron nitride for use in bonded coatings.

The resistance of molybdenum disulfide to gases at elevated temperatures was investigated by Eckert [271] to obtain data on the lubricating properties at such temperatures. Information on the decomposition temperatures in air, hydrogen, and hydrogen-nitrogen mixtures was presented.

Bowden and Rowe [272] found that films of molybdenum disulfide formed by heating molybdenum in hydrogen-sulfide gas or in carbon-disulfide vapor gave low friction at high temperatures even in vacuo.

The frictional properties of steel subjected to various surface treatments and lubricated with molybdenum

disulfide were investigated by Milne [273]. Results indicated a beneficial effect from both phosphate and sulfide pretreatments.

Miscellaneous. Berkey [274] reviewed the results of the various programs sponsored by Wright Air Development Center for the development of improved lubricants and suitable screening tests for lubricants for aircraft gas-turbine engines.

A study of the properties of fluids and lubricants which show promise for application in the 500 to 700-F range was reported by Klaus and Fenske [275]. Test procedures and techniques were described for the measurement of viscosity, lubricity, corrosion and oxidation, and thermal stability in the specified temperature range. The inadequacy of extrapolating 200 to 350-F data to predict 500 to 700-F performance was shown.

Three new silicone fluids for application as high-temperature lubricants and hydraulic fluids were reported by Brown [276]. Data on lubricity, thermal and oxidative stability, and viscosity-temperature characteristics were summarized.

The oxidation characteristics of hydrocarbon lubricating oils in the presence of alkali were investigated by Ingold and Puddington [277]. Alkali was found to increase the oxidation rate but suppress totally sludge and varnish formation.

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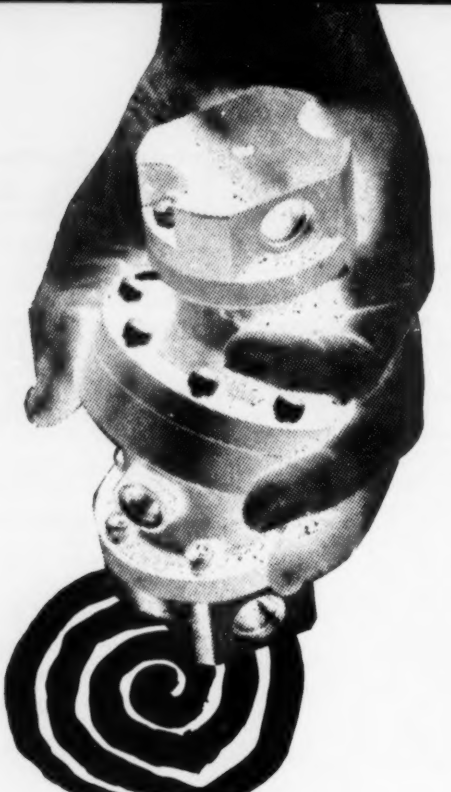

HOT-GAS

By William Patterson[1]

Vickers, Incorporated
Detroit, Mich.

For aircraft and missile auxiliary power, here is a compact, self-contained, positive-displacement motor driven by hot gas from a propellant charge

Fig. 1 The Vickers-type axial-piston, hot-gas motor, a modification of a hydraulic motor. A pump for hydraulic power output can be integrated with the motor package.

THE expanding requirements of missiles and high-performance aircraft create an urgent need for improved sources of auxiliary power. Auxiliary power units (APU's) must be light, compact, and reliable; they must provide rapid response at high force levels, throughout a wide range of ambient conditions. Hydraulic systems are capable of satisfying these criteria, but the source of secondary power constitutes a major problem in space-age vehicle development.

How Much Power...For How Long?

Current and anticipated future auxiliary power requirements are classified by vehicle type in Fig. 2, indicating approximate power levels and operating periods.

Aircraft auxiliary power systems are used for operation of aerodynamic control surfaces, landing gear, communications equipment, and other related functions. Power requirements range from less than one horsepower to several thousand (for the next generation of long-range supersonic bombers).

In addition to the basic aircraft requirements, missiles require auxiliary power for environmental control, guidance systems, and trajectory control. Because of the variety of special missions, missile requirements encompass a broad span of power levels and operating times. Short-range or interceptor-type missiles demand from 2 to 10 hp for durations of 10 sec to 10 min; long-range ballistic missiles require 10 to 30 hp for one minute to a half hour or more.

Boost-glide vehicles, satellites, and similar spacecraft are divided into two categories. Unmanned vehicles presently require low auxiliary power levels for relatively long periods of operation, while plans for manned vehicles call for 10 to 50 hp for only 1 to 10 hr. Anticipated requirements for future manned space vehicles exceed 100 hp for more than 10,000 hr.

The Hot-Gas Motor

Typical prime movers for auxiliary power units include battery-powered electric motors, gas turbines, and positive-displacement motors. Only recently has consideration been given to the use of a positive-displacement motor driven by hot gases from a propellant charge. As a prime mover, this unit combines the advantages of compact propellant energy and moderate rotating speed with the inherently high efficiencies of positive-displacement machines. It offers a unit capable of providing satisfactory operation under the severe conditions imposed by a superheated, nonlubricating working fluid.

The hot-gas motor APU consists essentially of an electrically ignited hot-gas generator and an axial-piston motor, modified from a hydraulic motor. A representative Vickers-type motor is illustrated in Fig. 1. To provide hydraulic power output, a positive-displace-

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MOTOR

... AN AUXILIARY POWER UNIT

ment pump can be integrated with the motor package. A regulator valve can be incorporated to maintain constant gas pressure, thereby providing constant hydraulic pressure. A typical hot-gas APU circuit is diagrammed in Fig. 3.

As a missile component, the hot-gas APU will furnish hydraulic power for flight controls and generator drives. An electric generator, together with a hydraulic-drive motor, can be integrated with the APU package. In this case, a constant-speed motor can be used as a generator drive to provide voltage and frequency regulation.

For applications requiring short-duration peak demands, a hydraulic accumulator can be included in the APU package to supply the power peaks while enabling a reduction in component sizes and propellant weight.

Advantages

The basic motor design has undergone several years of development engineering to improve contamination tolerance and high-temperature capabilities. Relatively large ports and cylinders enable the use of almost any gas-generating material. As a positive-displacement machine, this motor offers higher efficiencies than a turbine, particularly at off-design points. Better specific fuel consumption and lower system weight can be realized. The rotational speed of a positive-displacement motor closely matches the operating speeds of hydraulic pumps and electric generators; consequently, no gearbox is needed.

Routine servicing of the hot-gas motor is essentially the same as for its hydraulic counterpart. Recharging of the gas generator involves simple replacement of the igniter plug and propellant charge. During operation, control of the APU is simple and automatic.

Mechanical Description

As shown in Fig. 1, the axial-piston motor contains nine (or eleven) pistons. These are connected to the end of the drive shaft by ball-and-socket-type connecting rods. The cylinder block is synchronized with the drive shaft by means of a double universal coupling. The angle between the cylinder block and drive-shaft axes is a matter of selection and determines the length of the piston stroke. Hot gases enter through a stationary valve plate during all or part of the power stroke, depending on the choice of a full—or partial—admission design. Spent gases are exhausted through the valve plate during the return piston stroke.

This basic hydraulic-motor design must be modified to enable operation on hot propellant gases. High-wear-resistant metals with nearly identical properties of thermal expansion are used for the pistons and cylinder block. The shaft seals are omitted and a special valve plate is provided to withstand the severe conditions of friction and temperature. The motor housing is pressurized with hydraulic fluid, thereby minimizing internal gas leakage while providing lubrication for rotating parts. This fluid also acts as a heat sink to dissipate heat from motor parts exposed to the propellant gases.

When a hydraulic pump is integrated with the hot-gas motor, the two units share the same shaft, main bearings, and housing. Shaft seals are eliminated in both units, and the entire case is pressurized with hydraulic fluid.

The Working Fluid

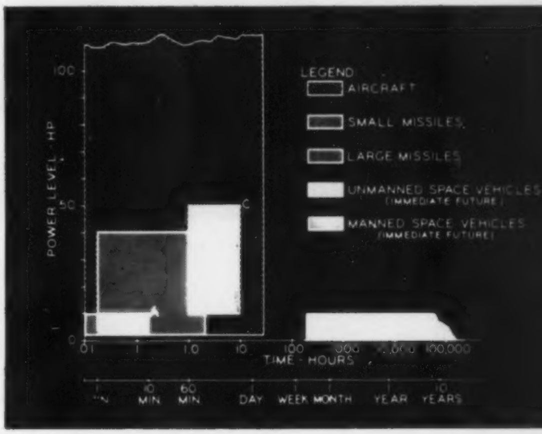
The hot-gas generator consists of a steel tube for holding the propellant charge and an igniter plug to initiate combustion. A rupture diaphragm is provided to prevent a dangerous pressure build-up in the event the outlet becomes clogged. The propellant is encased in an inhibitor to insure uniform end-burning.

A hot-gas regulator valve maintains constant inlet gas pressure. This valve consists of a poppet piston, spring, and seat. The poppet seat is contoured to afford self-cleaning action and prevent the accumulation of solid combustion products around the relief orifice.

Case pressurization for the unitized hot-gas motor pump may be easily provided by connecting the case to the hydraulic pump outlet through a pressure-reducing valve.

The gas inlet volume is small, and pressure increases

Fig. 2 Auxiliary power requirements, by vehicle classification. Possible sources of this secondary power are under intensive investigation. This paper reports on a piston motor served by a propellant charge.



rapidly; consequently, hydraulic flow is produced with a minimum time lag. It is possible to vary the burning rate with the load to best use available energy.

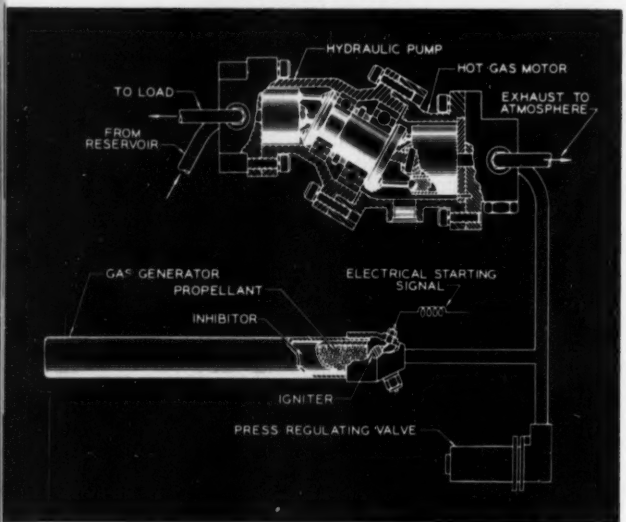
Depending on the application of the hot-gas APU, there are three possible means of pressure regulation.

The Gas-Regulator Type. Constant gas pressure is maintained by a pressure regulator in the motor inlet line. As the load on the hydraulic circuit is increased, the gas pressure tends to rise. This causes the regulator valve to open wider and exhaust more gas, preventing pressure increase. Conversely, a decrease in hydraulic load tends to lower the gas pressure, causing the regulator to close and exhaust less gas.

The Hydraulic Relief-Valve System. The gas regulator is supplanted by a relief valve in the hydraulic load circuit. This valve maintains essentially constant pressure for all load flow rates, providing that slightly more flow is pumped than required by the maximum load demand. Operating speed remains nearly constant, and stalling is prevented at low load flow rates. A hydraulic accumulator can be utilized to supply additional fluid flow for short-duration load peaks.

A Pressure-Compensated Pump. Pump displacement is varied in response to small changes in outlet pressure. As the load flow demand is reduced, outlet pressure tends to rise; this produces a reduction in pump displacement and outlet flow, preventing additional pressure rise. An increase in load flow demand causes a slight drop in outlet pressure and a resultant increase in pump displacement and flow.

Fig. 3 The circuit for an auxiliary power unit (APU) using the hot-gas, positive-displacement motor. Recharging involves simple replacement of the propellant charge and igniter plug.



The pressure-compensated pump provides hydraulic-pressure regulation for varying load flows without dissipating hydraulic power through a relief valve. If a propellant is used which decreases its burning rate as gas pressure decreases, a definite saving can be realized in gas generator and propellant weight. Overheating of the hydraulic fluid as a consequence of excess power dissipation is also avoided.

The Propellant Charge

Propellants are available in various compositions which give combustion-chamber pressures of 500 to 2000 psi and temperatures of 1500 to 2500 F. For power levels under 10 hp and operating times of several minutes or less, solid propellants seem to have definite advantages in terms of storability, simplicity, and energy content per unit weight or volume. For longer operating times, liquid propellants offer the advantages of low specific fuel consumption (usually translatable into lower installed weight and smaller space). Because most auxiliary power requirements are of a varying load character, the liquid propellant enables better control than is presently possible with solid propellants.

Use of liquid propellants carried specifically in missiles was considered. Since most of the main propulsion fuels and oxidizers have extremely high burning temperatures (in the neighborhood of 3000 to 5000 F), operation of the hot-gas motor under these conditions was investigated. One series of tests utilized hydrogen and oxygen with a reasonable degree of success. Initial tests were attempted burning a hydrogen-rich mixture to achieve a burning temperature of 2000 F. A later run was made with a near-stoichiometric mixture of the hydrogen and oxygen, resulting in estimated flame temperatures of 5000 to 5200 F. It would be fallacious to say that the test under these conditions was a complete success; nevertheless, satisfactory operation was obtained for 39 seconds. Upon disassembly, motor components were found to be in excellent condition. The test was halted because of rupture of the stainless-steel line connecting the combustion chamber to the motor inlet.

Fig. 4 shows a recent experimental motor pump, indicating the small size of this compact, 10.8-hp unit.

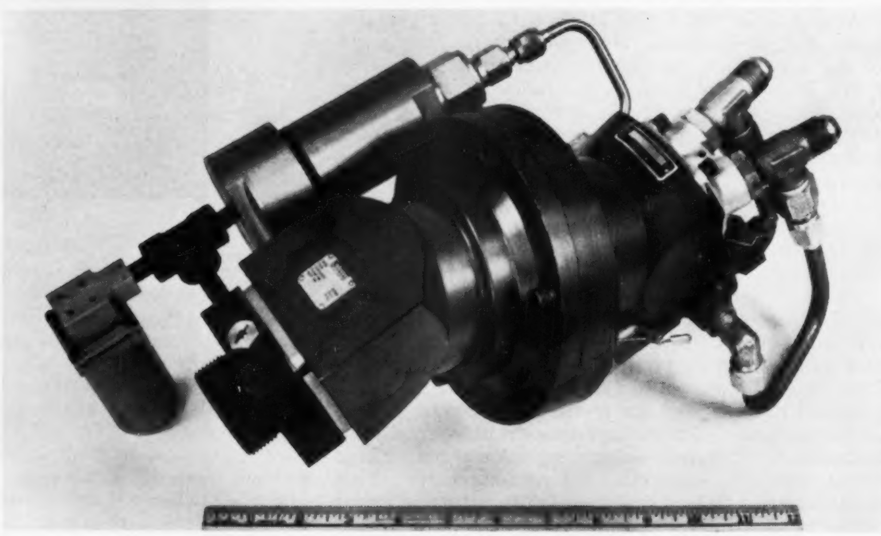


Fig. 4 A recent experimental motor pump, showing its compactness. The hot-gas, positive displacement motor appears to offer advantages over a turbine drive in terms of weight and efficiency.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Abstracts and Comments Based on Current Periodicals and Events

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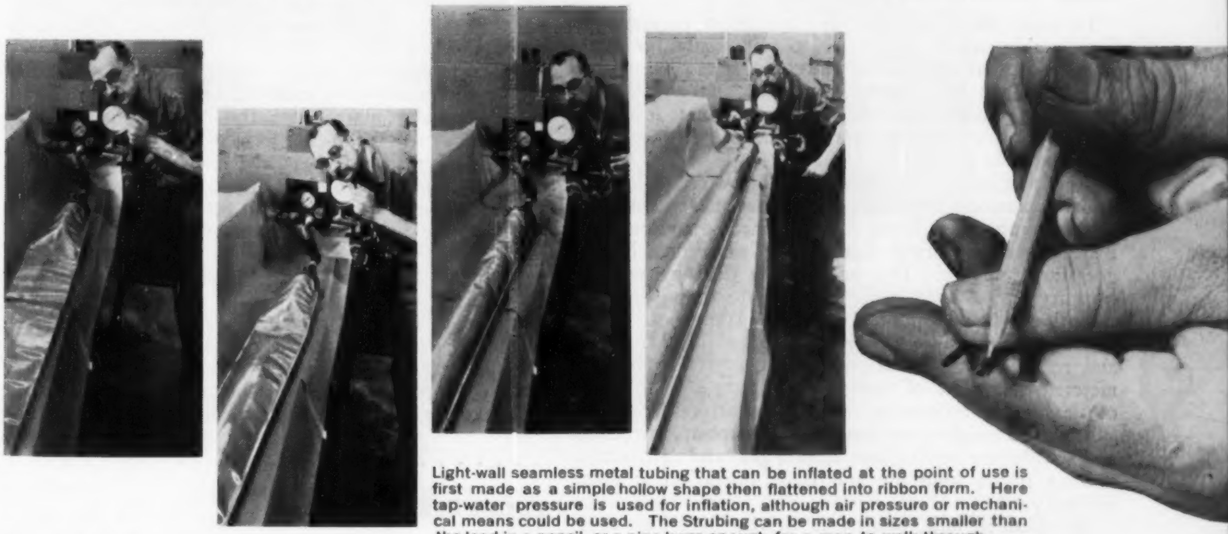
BRIEFING THE RECORD



Light-wall seamless metal tubing that can be inflated at the point of use is first made as a simple hollow shape then flattened into ribbon form. Here tap-water pressure is used for inflation, although air pressure or mechanical means could be used. The Strubing can be made in sizes smaller than the lead in a pencil, or a pipe large enough for a man to walk through.

Inflatable Metal Tubing

Experimental production of light-wall seamless metal tubing that can be shipped in ribbon form and inflated at the point of use is being started this fall by Wolverine Tube Division of Calumet and Hecla, Inc., Allen Park, Mich.

Point-of-use inflatability makes it possible to ship thin-wall tubing economically—since only the tube "walls" are shipped and not the "hole." The process used in making "Strubing," technically classified as cold rolling, is very economical. It provides a means of producing thin-wall round tubing of materials and in thicknesses either unavailable today or available only at a prohibitive cost.

The methods and equipment to be used for inflating Strubing will probably vary with application of the material and its dimensions. The company's engineers have used hydraulic pressure, air pressure, and mechanical means to "inflate" Strubing. The thinner the wall thickness, obviously, the lower the pressure required to inflate Strubing. In some sizes, Strubing can be inflated simply by using tap-water pressure.

Strubing can be made in sizes ranging from smaller than the lead in a pencil to a pipe large enough for a man to walk through. It can be made as thin walled as household metal foil or as thick walled as conventional pipe. It will be possible to ship Strubing in coil lengths of as much as 15,000 ft.

Techniques involved in making Strubing are reported to be basically very simple. The first step is to make a simple hollow shape by conventional techniques. This is then passed through a rolling mill where it is flattened into ribbon form. The rolling process used elongates the original tube by making it thinner without changing the ID. The more passes through the rolls, the thinner the Strubing. The diameter of the Strubing is limited only by the size of the starting piece, and the size of the starting piece is limited only by the capacity of the rolling mill used.

Inherent in the product produced by the rolling process is a pair of fins or ribs on the outside which provide added stiffness. If desired, the fins can be removed as the Strubing is being formed.

The process for making Strubing is based on patents and patent applications held by inventor Howard A. Fromson of New York City. Calumet and Hecla has exclusive United States and Canadian rights to their use.

An entire round heating-system ductwork for a 7-room house can be shipped in a box the size of an orange crate instead of in trailer-truck loads. The Strubing "ribbon" might be strung through the house and then inflated right in place—for a major saving in time and effort over conventional installation methods.

Downspouts and electrical conduit would be other

household uses with a commercial equivalent in sheathing for power-distribution and communications cable.

Low-cost, corrosion-resistant inner lining for piping, and vessels for the chemical, petrochemical, and process industries could be made of a corrosion-resistant material such as tantalum and ordinary steel. The Strubing would be inserted in a pipe or tank and inflated to provide a protective lining.

This technique could also be used for repairing sewer and water mains that develop leaks. It would be unnecessary to rip up a street or other ground surface to remove and replace sections of pipe.

Vapor-Compression Water Still

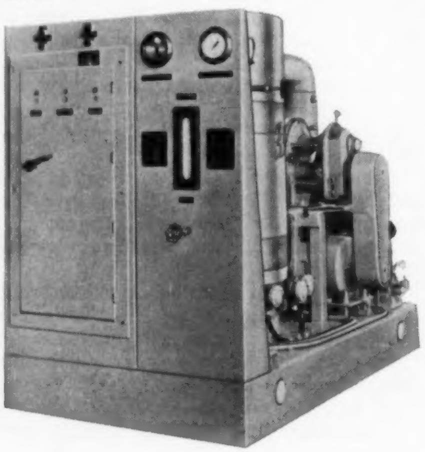
To MEET the 20-gal per day per man requirement for potable water and other requirements for low-mineral-content water, the Navy's nuclear submarine *Skate* will use heat from the reactor and an electric-powered auxiliary unit. While the reactor is in operation, the ship's steam-propulsion plant distills water at a rate up to 4000 gal per day.

When the steam-still reactor is inoperative and when diesel operation is necessary, a compact electric-powered Vapor-Compression Water Still, engineered and built by Badger Manufacturing Company, Cambridge, Mass., goes into service. The unit has a 2000-gal per day capacity and a high ratio of distillate to power consumption. It incorporates a special compressor made entirely of standard Navy M bronze for durability and resistance to corrosion. The compressor delivers metered quantities of vapor or gas over a wide range of pressure and no internal seal or lubrication is required.

Two figure-eight impellers rotate in opposite directions and a wide-face herringbone timing gear and antifriction bearing insure long life and quiet operation at rated efficiency.

The Badger unit, which is driven by a 440-volt, 3-phase, 60-cycle electric motor yields about one part of distillate to $1^1/_2$ parts of sea water pumped into the plant.

Distillate is pumped to three kinds of storage tanks. From one of these, it is blown by air to taps that serve as outlets for the ship's hotel uses. From the reserve feed tanks, it is vacuum dragged to condensers for steam-plant make-up. From charging water tanks, it is pumped to the main coolant system and outlets used for filling batteries.



A compact electric-powered vapor-compression water still yields about 1 part of distillate to $1^1/_2$ parts of sea water

Automatic Monitoring of Railroads

TELEVISION MONITORING of freight trains traveling at high speed becomes possible with the Videograph Electrostatic Printer. This is a high-speed duplicator based on television principles developed by Stanford Research Institute, Menlo Park, Calif., for the A. B. Dick Company at the request of the New York Central Systems. In place of an image on a screen, the Videograph produces a permanent printed record of what the television camera sees.

For train make-up and routing it is necessary to record the number and type of each car in a train. At present this is usually done manually, then telegraphed or telephoned to the next freight-yard switch point. Closed-circuit television is also used for this purpose, but the numbers still must be recorded by hand, and the train must move slowly to prevent blurring.

Under the new system a railroad yardmaster will receive a picture of each train en route to the freight yard many hours before the incoming cars actually arrive.

When a train approaches, floodlights positioned beside the tracks at an outlying station will turn on, and the camera will record the image of the cars as they pass. The picture will be transmitted by coaxial cable or microwave relay to the printing equipment at the

Future Power Market

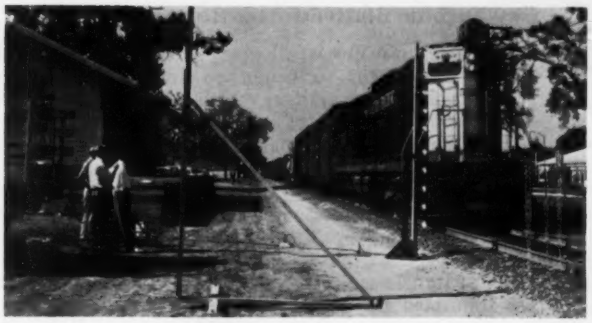
EVERY five years since 1944, Westinghouse Electric Corporation has held a Future Power Market Forum which takes a conservative look (judging by performance in relation to previous estimates) at the power market for the future, the factors which will influence it, and the engineering developments required to meet it.

Predictions indicate that the installed electrical capacity required in 10 years will be 295 million kw (present 145.9 million kw). The industrial market will require 667 billion kwhr, the commercial 216.8 billion kwhr, and the residential 408 billion kwhr.

Contributing Factors. Some of the many factors contributing to the anticipated increase for industry, aside from substantial population growth, are: (*a*) Beneficiation of taconite which requires about 70 kwhr per ton of finished material; (*b*) sintering which requires 25 to $27^1/_2$ kwhr per ton of sinter; (*c*) the steady increase in the use of electricity for materials handling, automation, and other requirements in manufacturing automobiles—900 kwhr per car in 1949, 1500 kwhr per car today, and 2000 kwhr per car by 1963; (*d*) numerical control of machine tools—17 billion kwhr today, 23 billion kwhr by 1963, and 28 billion kwhr by 1968; (*e*) chemical-industry requirements—59 billion kwhr now, 81 billion kwhr in 1963, and 139 billion kwhr in 1968.

During the next decade $500 billion will be spent on new commercial construction for sales and office structures using increasingly higher levels of illumination

Car numbers are very clearly visible in the permanent pictorial record



Freight trains are automatically recorded by television with the aid of floodlights as the train passes an outlying station at high speed. The image is transmitted by coaxial cable or microwave relay to an electrostatic printer which produces a continuous permanent paper-tape image.

Black powder clings proportionally to the electrically charged areas of the paper tape

freight yard where the signal will deposit electrical charges on a continuous paper tape. These charges correspond to the dark areas of the image. The tape is then dusted with black powder, which clings to the charged portions of the tape. This is heated and permanently pressed into the paper.

The same Videograph equipment, currently in the laboratory-prototype stage, could also be used to transmit printed material such as way-bills throughout an entire railroad network. The system is extremely rapid—it can duplicate and print out 17,000 elite typewriter characters per sec.

and display lighting. Existing structures will be maintained and modernized at a cost of $250 billion during the same period. Integrated shopping centers, not only in suburban areas, but on the scale of multiple-block developments in central-city areas with surface traffic replaced by underground servicing, access, and parking will play a spectacular part in the development of the commercial-power market.

The total electric home—electrically heated and cooled as well as lighted, with electrically prepared meals, and with a plentiful supply of electrically operated entertainment devices—is an industry goal that is coming closer to realization and will influence the residential-power market.

Engineering to Meet the Needs. Greater efficiency in all phases of the power industry will be required to meet these demands. Automatic dispatching is already in operation in a few spots and a wholly automated power plant was recently installed.

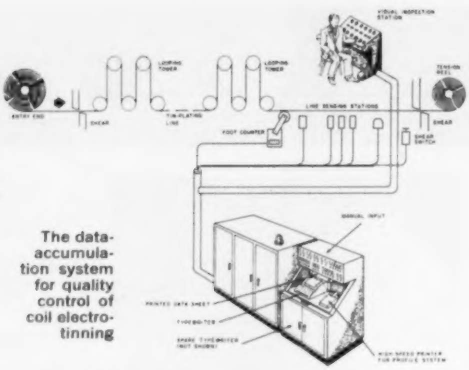
Westinghouse, in a joint study with Public Service Electric and Gas Company, has set up a mathematical model of that N. J. utility's system. Using Monte Carlo techniques for the random events involved, and high-speed digital-computer calculation, 20 years of system operation are compressed into less than 20 minutes and the computer prints out a whole expansion program showing when additions will be needed and takes the guesswork out of financial planning.

Extra-high voltages, above 250 kv, will effect economies in the transportation costs with single-circuit capabilities of a million kw reducing the number of circuits required over limited rights of way. Long-distance-transmission range is improving to the point where it will be possible to take advantage of the shifting demand peaks which follow the sun across the continent.

Generating Efficiency. Where it took 1.5 lb of coal per kwhr to generate electricity in the 1920's, it takes only 0.65 lb now and this may be at the point of diminishing returns except for new metals developments, and combinations with other types of power generation. Combined gas-steam cycles will use combustion gases from the fuel both to generate steam and to drive a gas turbine for higher thermal efficiencies if fly-ash-separation problems can be solved. Thermoelectric generation from the heat in a gas-turbine exhaust may be another auxiliary possibility.

Other Equipment. Inner cooling has made possible larger generators. Transformers, too, have gone from 60,000 kva in a weight of 500,000 lb to 300,000 kva in the same weight—a fivefold increase. Fluorocarbon-vapor cooling will make possible further reductions. Distribution transformers have gone from 50 kva, the largest possible for pole mounting in 1928, to 100 kva in 1944, 250 kva now, and a probable 333 kva in the future. Breakers have increased in kva rating 10 times.

One of the most spectacular claims in the atomic-power field is that the company is now fully prepared to develop, design, and construct a 330,000-kw plant that will produce power at costs competitive with fossil fuel in the higher-fuel-cost areas of the country and be ready for operation in four years!



The data-accumulation system for quality control of coil electro-tinning

Automated Quality Control

A SYSTEM that automatically accumulates, records, and prints deviations in the quality of tinplate coils has been developed by Airborne Instruments Laboratory, AIL, a division of Cutler-Hammer, Inc., Mineola, N. Y.

One of the systems has been sold to Inland Steel Company and has been so designed by AIL that: (*a*) It makes use of the existing sensing stations at Inland Steel, and (*b*) automatically records—either on a printed ticket, or punched paper tape—the extent of the deviations in the predetermined characteristics of every coil of tinplate manufactured in a production run.

The coil data-accumulation system consists of a visual inspection station, a main cabinet, and an output cabinet—together with interconnections to existing sensing gages on the electrotinning line.

When a coil is entered into the line, the operator sets the knobs on the manual-input cabinet to indicate the date, turn, crew, coil order number, temper, base weight, line operation, and strip width. Large in-line numbers located above each group of knobs help the operator to adjust the knobs for the correct numerical settings. These numbers are converted into typewriter code signals by switching circuits. Numbers representing the time are generated by a clock in the cabinet and are also converted into typewriter code. The typewriter-code signals are then transmitted to the electric typewriter in the output cabinet which records all information received from the manual-input cabinet on a preprinted form.

The visual-inspection station is located at the end of the tinning line near the shear. Defect buttons on the control panel of the station correspond to the types of visual defects that may be present in the strip. When the inspector observes a defect in a strip passing by the inspection station, he presses the button on the panel corresponding to that defect, and holds the button down until the defect is no longer observed in the strip. A lamp located above each defect button lights during the time that the defect button is depressed.

The main cabinet is located near the shear at the output end of the electrotinning line. It contains three independent computers for maximum reliability, a comparing circuit, and a trouble indicator. Each of the computers in the cabinet is completely enclosed in a dustproof cabinet; a number of external test points are provided for operational checks.

The output cabinet is located near the shear at the output end of the electrotinning line. It contains a typewriter in the top section of the cabinet and a spare typewriter (in a sealed package) in the lower section of the cabinet. Dust shields are provided to protect the operating parts of the typewriter.

A coil-profile data-accumulating system is provided giving a printed record of the location of all defects in 10-ft increments.

Gas-Turbine Blast-Furnace Blower

THE first blast-furnace-blowing gas turbine has had its final tests at the Westinghouse steam division plant in Lester, Pa. The system, which will supply 125,000 cfm of air to blast furnaces at U. S. Steel's South Chicago Works, represents more than seven years of research to determine the advantages over conventional methods. The gas-turbine system is not only lower in initial cost, requires less space, and uses practically no water, but should have lower operating and maintenance costs.

A boiler is not required in its auxiliary equipment since the blast-furnace gas is burned directly in the gas turbine. The connected axial compressor supplies air both to the blast furnace and to the combustion system of the gas turbine.

Self-Leveling Buildings

WHENEVER the radar facilities being installed in two five-story buildings on the Greenland icecap tilt out of level, a push of a button will put things back on an even keel. Not only will the 32 14-ft-high jackscrews which support each building, keep it level, but they will maintain a 15-ft clearance above the icecap in spite of varying accumulations of snow and changes in temperature.

Each of the jackscrews made by Standard Pressed Steel Company, Jenkintown, Pa., for Perfecting Service Company, Charlotte, N. C.—the designers and manufacturers of the lifting and leveling system—can sustain a load of more than 800 tons. Each weighs 1000 lb and will withstand a straight pull of 1,600,000 lb, or 90,000 psi.

The studs were machined out of heat-treated ASTM grade (4340-type) alloy-steel bar. Lift nuts were made from bronze-aluminum-manganese castings. Some of the studs were precision threaded for as much as seven consecutive feet.

The two DEW-Line stations are being built by Peter Kiewit Sons' Company of New York City for the Army's Corps of Engineers.

Self-leveling five-story buildings will be built on the Greenland icecap to provide accommodation for accumulations of snow

Nuclear Briefs

▶ "Strange" Particle's Existence Proved

Photographs exhibiting the presence of "strange" particles of antimatter called antilambdas have been taken in the new 6-ft bubble chamber at the University of California's Lawrence Radiation Laboratory.

The new subnuclear unit is the third particle of antimatter to be created and discovered with the great Bevatron. Earlier ones are the antiproton (discovered in 1955) and the antineutron (1956).

▶ Nuclear Seaplane

The Navy has awarded a $127,000 contract to the Martin Company, Baltimore, Md., for the study of airframe designs for a nuclear-powered antisubmarine-warfare seaplane with turboprop engines.

Marriage of a nuclear reactor with a turboprop engine would greatly improve the range and endurance of seaplanes, and the contract is part of an over-all program, aimed at putting a nuclear seaplane in the air "by 1964," on which the Navy spent $12.4 million for the fiscal years 1955–1959.

Martin's design studies will concentrate primary attention on propulsion work under way elsewhere on development of an indirect-cycle engine. The Navy considers this more suited to nuclear seaplanes in the 60 to 100-mw range than the direct-air-cycle engine.

Among the fundamental drawbacks of the direct air cycle is the divided rather than unit shield which exposes all of the equipment to radiation. Heavy shielding around the reactor in the Martin design would minimize the exposure of crew and equipment to radiation.

▶ Zero-Gradient Proton Synchrotron

The Atomic Energy Commission has broken ground on its new $29-million Zero-Gradient Proton Synchrotron at the Argonne National Laboratory, Lemont, Ill. The doughnut-shaped particle accelerator will produce 12.5 Bev and will be used to study the properties of fundamental particles and the behavior of the so-called "strange" particles.

▶ Miniaturizing Particle Accelerators

A new machine, named "Megatron" by its developers, will make possible the study of new principles of high-speed acceleration of charged particles—electrons, protons, or charged nuclei.

Megatron is short for "mega-gauss betatron." Electrons and protons are speeded up simultaneously by magnetic induction in a rapidly changing high magnetic field. The electrons attain an energy of 150 million volts in five millionths of a second.

These principles may make possible the construction of accelerators of very high energy but small physical size. Ultimately, a machine comparable to the 2-mile-long accelerator currently being developed at Stanford University, may occupy only the area of a regular desk, yet provide the extremely penetrating radiation with which the internal structure of the atom can be studied.

The megatron was conceived by David Finkelstein early in 1957, was developed further by him while at Brookhaven National Laboratory and at Geneva. It is being constructed in the Physics Laboratory of Stevens Institute of Technolgy under joint supervision with Kenneth C. Rogers, another member of the Physics Department staff.

▶ Thermal-Breeder-Reactor Program

The Atomic Energy Commission has inititaed a long-range program at Oak Ridge National Laboratory to develop effective thermal-breeder reactors which would make full use of the latent energy in thorium.

In the initial loading of the thorium-uranium cycle, thorium is inserted in a reactor, fueled with either U-235 or U-233. The chain reaction is sustained by the uranium while the thorium is converted to new U-233. This is then available to replace the fissionable material used during the reactor's operation. More fissionable material is produced than is consumed.

The new program has as its objective the development of a thermal-breeder reactor capable of converting thorium to fissionable-fuel material at a doubling time of not more than 25 years. This would mean that a reactor would produce enough excess fissionable material in that time to start up a second similar reactor.

Because all three fluid-fuel reactors previously under development for the AEC were found by a special task force of engineers and scientists to be potentially capable of development as breeder reactors, the new thermal-breeder program may include one or more of these concepts. These are the aqueous-homogeneous, molten-salt, and liquid-metal-fueled reactor projects. Brookhaven National Laboratory and the Babcock & Wilcox Company were developing the Liquid-Metal-Fueled Reactor and Oak Ridge National Laboratory was working on the other two.

▶ Small AEC Pressurized-Water Plant

The AEC is designing a small-sized pressurized-water reactor to be completed by May, 1962. Co-operatives and public-power organizations are invited to participate by providing, as a minimum, the site, the conventional turbogenerating facilities, and certain other services. If no satisfactory proposal for participation is received, the AEC will consider constructing the plant on its own site and at its own expense.

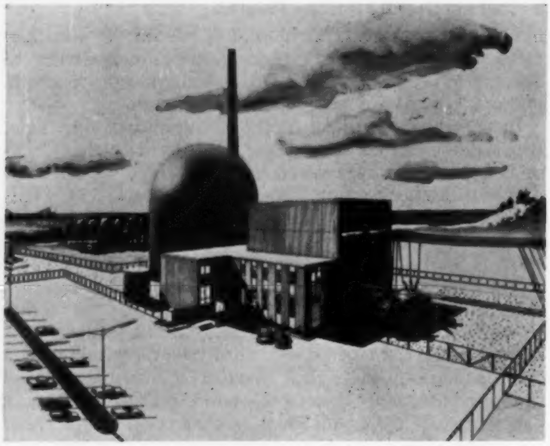
A significant contribution to achievement of economical electric power in a small-sized plant will be the major objective. The pressurized-water concept was selected because of the advanced state of the technology and because no plant of this type is currently being constructed in this size range.

The proposed plant would generate about 60,000 tkw and 16,500 ekw. A superheater which would increase electrical capacity to 22,000 kw could be included at the option of the participants.

▶ Advanced Epithermal Thorium Reactor

A 360,000-kw Advanced Epithermal Thorium Reactor, AETR, in which sodium would be used as a coolant, thorium-uranium alloy as fuel, and beryllium or graphite as a moderator is being investigated by Atomics International. The study is being made for Southwest Atomic Energy Associates, a group of 15 investor-owned electric companies in seven states extending from Missouri to Texas.

The AETR is regarded as a natural evolution of the Sodium Graphite Reactor, a concept which has been under intensive investigation by Atomics International for a number of years. The AETR now in the critical-assembly stage offers substantial promise as an economic heat source for large-sized power plants because of more efficient utilization of nuclear fuel and high-temperature, low-pressure operation due to the coolant.



The 50,000-ekw direct-cycle forced-circulation boiling-water nuclear power plant to be built in Michigan

New Boiling-Water Nuclear Plant

Consumers power company will build a 50,000-ekw, direct-cycle forced-circulation, boiling-water nuclear power plant at Big Rock Point, Mich., on the Lake Michigan shore of the northern part of the lower peninsula.

In the forced-circulation system which will be capable of operating at 1000 to 1450 psi, water at near-saturation temperature will be pumped into the reactor vessel, flow upward through four 14-in. risers to the separate steam drum. After passing through mechanical steam separators, the steam will flow directly to the turbine. An emergency heat-exchanger system will condense reactor steam in case of a scram when the turbine and condenser are unavailable as the heat sink.

The high-specific-power, high-power-density plant, to be in operation in 1962, will have as its end result the capability of constructing single-unit plants of 200,000 to 300,000-kw capacity at capital costs in the range of $225 to $250 per kw. This represents an extension of the upper practical rating of about 100,000 kw and a reduction of about $100 per kw in capital costs.

The $30 million estimated cost of the proposed plant and related facilities is $10 million more than the cost of a similar-capacity conventional plant. The extra cost will be charged off as research-and-development expense until 1973. The company may apply to the AEC for limited research-and-development assistance and waiver of nuclear-fuel-use charge.

It is planned to increase the plant's capacity over a $4^1/_2$-yr period from 50,000 to 75,000 kw through technical improvements, particularly in reactor core and fuel design. Initially the fuel will be slightly enriched zircaloy-clad uranium pellets.

General Electric will furnish the nuclear portion of the project. The Bechtel Corporation, San Francisco, Calif., will be prime contractor. Commonwealth Associates, Inc., Jackson, Mich., will provide certain engineering services.

Consumers Power Company's participation with Detroit Edison and other utilities in the Enrico Fermi Nuclear Power Plant at Laguna Beach, Mich., will be unaffected.

Smaller Reactor-Containment Shells

The $15 to $35 per kw cost of the large cylindrical or spherical reactor-containment shell, used to house the reactor and associated equipment in a nuclear power station, is a major item in the total construction cost of these plants. Tests now being conducted by Sargent & Lundy, Chicago, Ill., may lead to important changes in design.

The company has felt for a long time that the size of containment shells could be reduced if provisions were made to quickly mix any escaping high-pressure boiling water with cold water thus preventing the large pressure build-up which would normally occur.

Test equipment consists of a 32-ft-high and 14-ft-diam vessel buried underground in a vertical position and capable of withstanding an internal pressure of 100 psi. Inside this vessel, which represents the containment shell, is a 23-ft-long, $3^1/_4$-ft-diam, heavily insulated steel drum used to represent the reactor. It holds 182 cu ft or 9000 lb of boiling water at a pressure of 600 psi.

Large diaphragms located at various places on the drum can be ruptured by a remote-controlled triggering device to simulate a rupture in the reactor system.

Cold water is contained in the bottom of the outer vessel and also at varying levels alongside the simulated reactor. Upon rupture of the diaphragm the complete content of the simulated reactor is discharged into the containment vessel in from 2 to 5 sec and is immediately mixed with cold water.

Modularizing the Steam Turbine

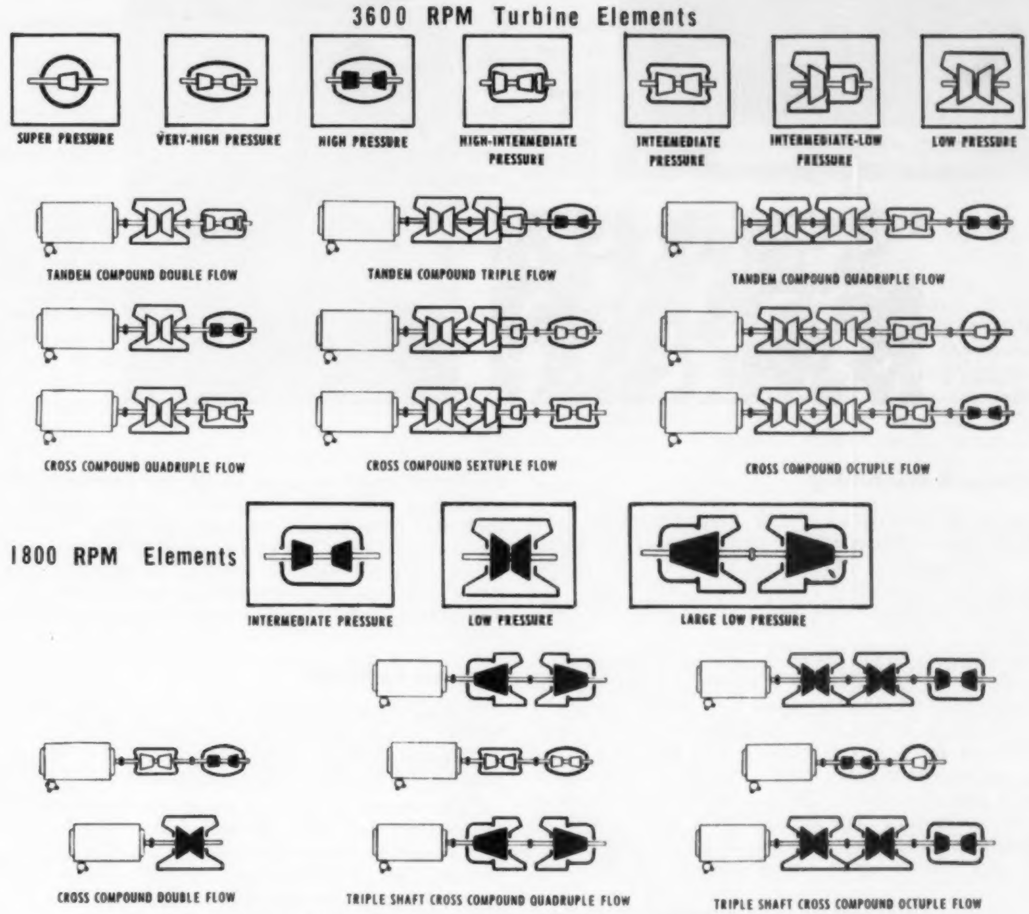
Advance development of large steam-turbine components is being used by Westinghouse to permit better manufacturing reliability and to pave the way for greater engineering research according to an article by H. R. Reese, Mem. ASME, manager, Advance Design Section, Large Turbine Engineering at the Philadelphia, Pa., plant, which appears in the July, 1959, *Westinghouse Engineer*.

Turbine arrangements have been analyzed into the basic elements that make up 3600-rpm and 3600/1800-rpm machines to illustrate the duplication of basic elements. The system would replace the traditional "custom engineering" for each specific application. Seven basic 3600-rpm pre-engineered machine components can be assembled in almost any combination for inlet steam conditions up to 2400 psig 1050 F with reheat to 1000 F. Machines of increased rating are produced by adding pressure and temperature front ends to the multiplicity of elements that made up the three basic arrangements.

In turbine arrangements, the same basic elements often are repeated in various combinations. In establishing a line of basic elements, there are these major considerations: (*a*) Range of steam conditions; (*b*) range of turbine ratings; and (*c*) turbine arrangements in which the elements will be used.

Evaluation of the requirements collectively shows that duplicate sets of major castings, including outer and inner cylinders, nozzle chambers, and gland cases can be used. A single composite spindle forging can act as a back-up for any one of a number of units. The manufacturing advantages of this situation are obvious, making possible shorter and more reliable delivery schedules.

An example of an element that has been given the full treatment is the high-pressure turbine element. This



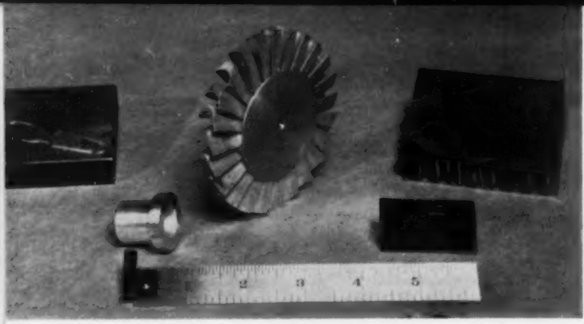
The 3600-rpm turbine elements illustrated in the top row can be arranged as shown in the following three rows, or combined with the three 1800-rpm elements shown in the center to make 3600/1800-rpm arrangements in the Westinghouse system for modularizing the steam turbine

element has been designed for a range of steam conditions from 1800 psig, 1000 F, to 2400 psig, 1050 F, for use in turbines rated from 175 mw through 325 mw. The element can be used in tandem-compound triple-flow, tandem and cross-compound quadruple-flow, and cross-compound double-flow 3600/1800-rpm arrangements.

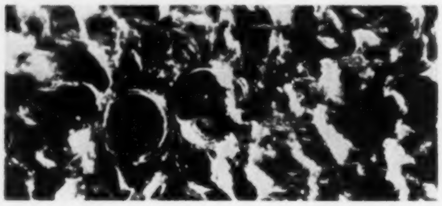
The consideration given to this high-pressure element is typical. This same philosophy is being applied to all basic elements. The 3600-rpm low-pressure turbine provides a temendous potential for duplication. Designs for these elements are nearing completion. They are not an adaptation of existing elements to form an integrated line of low-pressure turbines, but represent a new design based on the latest advancements. Air-flow-model studies have been carried out in the development laboratory to support the program. These experimental studies have been directed at all portions of the turbine through which steam flows. Such portions include entrances to the turbine casings, where a transition from pipe flow to an annular flow occurs, and the exhaust hood.

As a result of progress made in mechanical and thermodynamic design programs, turbine designers have been able to proceed with design layouts of 3600-rpm turbine elements using a new 28-in. last-row blade. Designers plan to adapt the 28-in. low-pressure elements to an entire line of turbines. This is a simple substitution for the tandem-compound, double and quadruple-flow units. However, each turbine arrangement must be given complete design analysis to determine its feasibility. For example, the higher ratings associated with the 28-in. end make questionable (from a mechanical-adequacy standpoint) the practicality of building the intermediate-pressure, low-pressure element used in the triple-exhaust turbine. The particular element is currently under study.

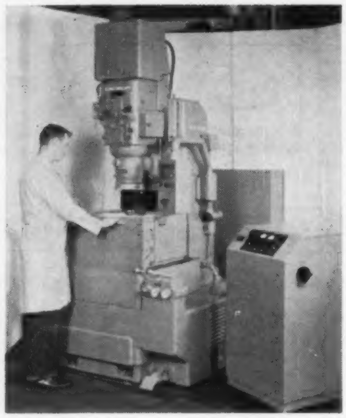
Such associated components as throttle valves, steam chests, interceptor valves, oil reservoirs, pedestals, and control systems can be pre-engineered in the same fashion as the turbine elements. For example, a study of throttle-valve and steam-chest sizes for reheat turbines ranging up to 325 mw revealed that only four sizes were needed. By holding dimensions of all the major parts fixed, the throttle-valve and steam-chest body forgings can be prestocked, providing a continuous flow of back-up forgings for critical parts.



Typical work performed with Elektrojet machines



Surface looks like this at 650 × magnification



When piercing or diesinking is performed on an Elektrojet, both part and electrode are hidden in an oil bath

Electrospark Machining

During the past decade a new class of machine tools has evolved which uses electric sparks to machine metal (see: "Electrospark Machining," by C. R. Alden, Mechanical Engineering, September, 1953, pp. 701–705; "New Metalworking Machine," December, 1951, p. 1007).

High-energy sparks pepper the surface at frequencies from 10,000 to 250,000 times a second. Each spark is an individual machining operation which makes a crater 1/1000 in. or less across, and about a third as deep. Where each spark hits it ejects a tiny molten glob of metal and vaporizes some more. Sparks are propagated across a gap of about 1/1000 in. between an electrode and the workpiece. The gap is usually bathed with an insulating fluid (dielectric) which helps control the spark and washes away the debris ejected from the crater.

One of the critical problems in electrospark machining has been to develop equipment that will remove metal at reasonable speed and at the same time produce fine surfaces. Two basic types of d-c electrical circuits have been adapted to the purpose. One is the r-c (resistance and capacitance) type. The other is the pulse type which operates at a frequency about 10 times that of the first.

The pulse type has been used in a new Elektrojet line of 33 electrical-discharge machine tools recently introduced by Cincinnati Milling Machine Company and specifically designed to solve problems in the areas of close tolerances, economical electrodes, big cavities, and in general dependability. The 33 modularized tools are built up principally from only 16 basic units—two bases, two slides, four workheads, four base-tank units, and four power supplies.

The Elecktrojet line is designed to produce bottom corner radii as small as 0.002 in. and bottom corner radii of 0.008 in. at regular production speeds are routine. Experimentally, a hole 0.00003 in. out of round had been produced on one of these machines. Large die cavities are being sunk with dimensional accuracy of ± 0.005 in. from the desired form. On smaller applications ± 0.001-in. accuracy is typical.

The upper limit of cavity size has been raised considerably by techniques for making inexpensive large electrodes and by development of heavy-duty but precise machines capable of maintaining the necessary 0.001-in. spark gap with large electrodes, while holding 10-psi dielectric flow pressure through the gap. Cavities of 50 cu in. are now being machined by Cincinnati Elektrojet, at metal-removal rates of as much as 0.016 to 0.018 cu in. per min. Die blocks up to 18 in. thick can be handled by the large Elektrojet diesinking machine.

Rail-Air Facilities

A new form of short-haul transportation in which VTOL aircraft would use railroad rights-of-way and equipment has been proposed by Edward G. Vanderlip, President of Vanguard Air and Marine Corp., Radnor, Pa.

"The urgent problem of passenger transportation between cities less than 500 miles apart and from center city to jet air terminals requires a radically new approach," Mr. Vanderlip said. "The conventional helicopter partially answers this need, but is economically limited in range."

Using Vanguard's proposed Model 18 "fan-in-wing" VTOL airplane as a basis, Mr. Vanderlip explained studies which indicate that the 40-passenger craft could operate over railroad routes at a cost of 3¢ per seat mile compared to about 20¢ per seat mile for helicopters. Landing facilities would be provided at regular railroad terminals in center-city locations by converting present structures or building new over-track platforms.

The railroads would provide all necessary communications, utilizing much of their present equipment. The VTOL planes would follow the railroad rights-of-way on which navigation facilities such as radar reflectors and beacons would be installed, and would normally remain at an altitude of less than 3000 ft to avoid interference with standard commercial flights. In extremely turbulent air the planes could use higher altitude, shifting to Federal Aviation Agency-controlled flights.

Conceding that there are many political and economic problems to be solved before such a transportation system could be inaugurated, Mr. Vanderlip said that he has already discussed his proposal with representatives of some major railroads and that joint preliminary studies have been in progress for several months. He foresees tremendous savings in the system and navigational requirements for low-level short-haul operations over the next decade if the present rail network can be employed by VTOL operators.

Industrial Jet Power

A new concept in the industrial-gas-turbine field is the result of a joint effort by the Cooper-Bessemer Corporation and Pratt & Whitney Aircraft. A modified Pratt & Whitney Aircraft J-57 jet engine will drive a Cooper-Bessemer-designed gas turbine, thus converting the jet's massive thrust into commercially usable horsepower. An experimental prototype is under construction at the Mount Vernon, Ohio, plant of Cooper-Bessemer.

By modification of the J-57—power plant for jet commercial fleets and advanced military aircraft—hot compressed gases that normally provide enormous thrust will be harnessed by the gas turbine for conversion into rotative horsepower.

Initially the new gas-turbine engine will be coupled to a centrifugal compressor to pump natural gas through cross-country pipeline systems. The J-57, which normally burns conventional jet fuels, was converted to burn natural gas taken directly from the main pipeline on which the unit is pumping gas.

According to R. L. Boyer, Mem. ASME, Cooper-Bessemer vice-president and director of engineering, who originally conceived the possibilities of this undertaking, "It can be anticipated that this experimental project will result in great operating economies compared with any gas turbine now in use, particularly in the area of installation and maintenance costs. The first turbine, a 10,500-hp unit, is now under construction and will be ready for field installation early in 1960.

"While the initial intent for the new stationary-power concept is gas-transmission service, the development is already opening up new possibilities for lower cost power on such applications as chemical and petrochemical processing."

Living in Outer Space

The psychological and physiological stresses on men in space will be tested in the world's smallest efficiency apartment—a space capsule being built by Minneapolis-Honeywell to simulate living conditions on a trip into outer space. The space-cabin simulator is being designed for research use by the Department of Astroecology of the Air Force School of Aviation Medicine at Brooks Air Force Base, Texas.

The capsule is designed for occupancy by two astronauts for a period of 30 days, and is an elliptical steel tank 8 ft high and 12 ft long. Ingeniously condensed within these confines are most of the comforts of home and a complex maze of scientific equipment.

Air Force personnel selected for the first month-long simulated space flight will find their space home equipped with comfortable executive-type chairs, a bed, sanitary facilities, food, and cooking facilities.

Every effort has been made to simulate the isolation of space. The space men will be unable to see out of their capsule. Atmospheric noise and disturbance will be superimposed on their radio circuits—their only means of communication. Any part of the cabin that might remind an occupant that he is still on the ground has been carefully disguised or obscured. The closed-circuit television cameras used to keep the occupants under constant observation will be concealed behind the control panel and will peer through inconspicuous openings. Observation ports on the side of the cabin contain one-way glass which is opaque from the inside.

The door of the capsule contains an airlock so that biological specimens can be passed out without appreciably changing pressurization and without direct contact between the astronauts and the research scientists.

Pure breathing air is furnished by a complex system of controls which automatically pumps in oxygen when needed, reduces carbon dioxide through the use of chemical absorption beds, pumps in nitrogen if required, and catalytically filters carbon monoxide.

To permit astronauts to smoke, the system includes a high-voltage electrostatic filter to ionize and trap dust and smoke particles. Heating and cooling elements provide temperature control and a humidity device can pull moisture from the air and store it along with the water supply.

Atmospheric controls for the cabin are designed so that either the occupants or researchers at the outside instrumentation and recording console can vary the pressurization, oxygen, carbon dioxide, temperature, or humidity. Final control is in the hands of outside monitors. Cabin pressurization, for example, can be varied over the range of sea level to 28,000 ft.

The space travelers will be allotted two quarts of water and 3000 calories of food daily. This will be nonperishable, so no refrigeration is required. A heating element will be provided to warm up soup and coffee.

They will have 2 cu ft of space, about the size of an overnight bag, to store their clothes and about 2 cu ft of storage space for personal belongings.

The subjects will be able to tell whether it is night or day only by clocks. Simulated flight conditions and problems will be presented to them on a television screen, to be solved with the controls on their panel.

Describing conditions in the space-cabin simulator, Lt. Col. George R. Steinkamp, chief of the Division of Space Medicine's Department of Astroecology, said: "The men who enter the cabin will be completely sealed off from the world to which they have grown so accustomed. Time will weigh heavily on their minds, and boredom will become their constant companion. The familiar day-night cycle they live by will be lost. Though they will be able to stand erect and move about a bit in the cabin, they will still be greatly cramped. Thirty days can be a very long time."

The occupants of a simulated space cabin will be completely isolated from their surroundings for 30 days

Reliability Engineering

A 40 PER CENT increase in percentage yield of high-performance miniaturized relays and a drop to 5 per cent in the over-all rejection rate have been achieved by Allied Control Company, Inc., with more rigid procedures in purchasing, storing, manufacturing, and assembly.

These results have been achieved at the same time that the relays have been reduced to one sixth of their 1945 size and one twelfth of their former weight. Shock resistance has been upped 10 times from 10 to 100 *g* and resistance to acceleration six times from 10 to 60 *g*. Standard operating ambient temperature, formerly -40 to $+75$ C is now -65 to $+125$ C. Frequency vibration range, formerly 10 to 55 cps, is now 10 to 3000 cps and intensity has increased as much as 300 per cent. Hermetically sealed relays, that 15 years ago were subjected to a simple leakage test by submergence in hot water, are now inspected by a mass spectrometer which will detect a leakage as small as 0.0000004 cu cm per sec.

Military specifications are so rigid, particularly for missile and aircraft applications, that 100 per cent inspection is employed not only for all electrical characteristics of the completed relays, but for critical components and parts as well. The test sequence used for stability tests is cumulative, each relay being subjected to all of the environments it is expected to encounter in the field.

Current trends in relay design are in the direction of further miniaturization, incremental spacing of terminals, adaptability to printed circuits and automation. Development programs are proceeding to push operating-temperature limits to 300 C and beyond. Most recently, radiation resistance has been included among the requirements in the selection of materials for relays with a high order of reliability.

Roller-Bearing Expansion Adjustment

APPROXIMATELY 14,000 specially designed, prelubricated, sealed, antifriction roller bearings provide a unique solution to a thermal-expansion problem in a water-jacketed hot-sulfur line 50 ft below the surface of the Gulf of Mexico. Expansion joints are not feasible in a buried casing. Furthermore, curvatures resulting from variations in the level of the Gulf floor and from the fact that it is impossible to adhere to a straight line in dredging-and-laying operations 50 ft below the surface of the water imposed loads which made bearings desirable. T. E. Cushing, Mem. ASME, of the Orange Roller Bearing Company, Orange, N. J., designed the installation.

The support points are at $19^1/_2$-ft centers for the entire 7-mile pipeline which is part of a $30-million Grand Isle mining project of the Freeport Sulphur Company located that distance offshore on a platform (MECHANICAL ENGINEERING, September, 1958, p. 78).

The bearings separate the 6-in-OD liquid-sulfur line from the $7^5/_8$-in-OD hot-water-jacket line which has a 14-in. outer casing. There are eight roller bearings at each support point, located two in tandem at 90-deg circumferential positions. The weight is 80 lb per running foot or 1560 lb per support point.

Each roller bearing is enclosed on five sides by a drawn steel cup, the brim of which conforms with and is welded to the surface of the semicircular plate, through which it projects. Two plates are welded together to form a tight band around the insulation for transferring load from the pipeline to the rollers.

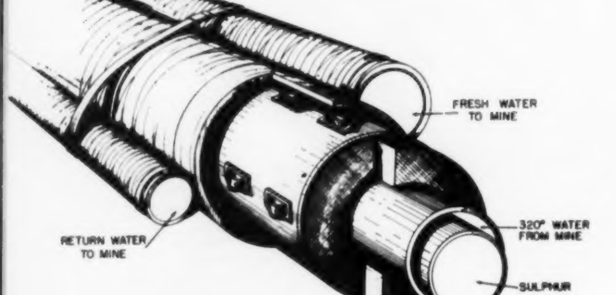
The bearing assembly consists of a hardened and ground pin, rolls, an outer race or roller, and two side plates which contact sealing rings seated in the sides of the outer race. The bearing is prelubricated by Socony-Mobil No. TR10 grease with moly, which was selected for its high film strength and resistance to oxidation at the service temperature. The bearing has a dynamic-load rating of 6000 lb, and an aircraft static-load rating of 24,100 lb, both calculated by AFBMA methods.

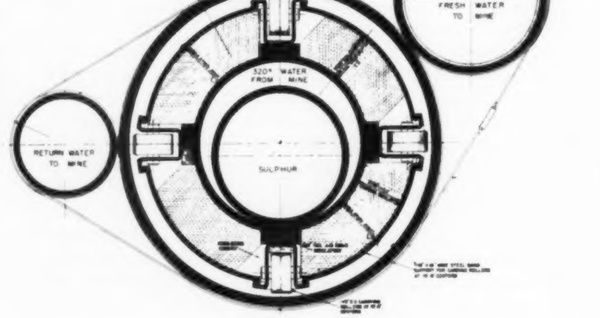
Loads do not necessarily act in the same direction and would combine vectorily. The combined load would be resisted by two rollers in tandem, or by four rollers at 45-deg positions, except for crossing a casing bell-and-spigot joint, at which only half as many rollers would carry the load. The roller and cup mountings are sturdily designed for resisting any twisting action that might develop during application or removal.

Available space limited the roller diameter to $1^3/_4$ in. and the crown radius of the roller was established at $6^1/_4$ in., which is 6 per cent less than the casing inside radius. For a maximum roller load of 3000 lb, the maximum stress in the center of the contact area between the roller and the casing, as determined by the Hertz method for curved surfaces in contact, is 182,000 psi.

The bearings also facilitate the insertion or removal of the pipe from the surrounding hot-water pipe, and a static load of considerable magnitude can be imposed on a bearing roller as a result of the prestressing given to the casing and inner pipelines.

Roller bearings accommodate thermal expansion and provide for easy insertion or withdrawal of a water-jacketed hot-sulfur line 50 ft below the surface of the Gulf of Mexico to bring sulfur to the mainland from an offshore well





High-speed semiautomatic gun drill reduces drill runout to an average of 0.002 in. per ft of hole depth for a $^{3}/_{16}$-in-diam hole

Installing heating elements with metal hangers driven into the insulating refractories of an atmosphere hardening furnace

Semiautomatic Gun Drill

A SEMIAUTOMATIC gun drill developed by the Griscom-Russell Company, Massillon, Ohio, has solved a troublesome drill-runout problem and has given unexpected dividends in new cost-cutting production techniques. Not only was the accuracy of holes increased but secondary finishing operations were eliminated.

Maximum runout with the new machines is 0.006 in. per ft of hole depth as compared to as much as 0.075 in. per ft for a $^{5}/_{8}$-in. hole with conventional twist drills. Hole size is held to within 0.001 in. and surface finishes of 15 microin. on a single pass are produced.

The semiautomatic machines at the Lahr Machine and Tool Corporation, Toledo, Ohio, were designed specifically for drilling holes in tube sheets of high-pressure feedwater heaters.

Two basic types of gun drill are used—a core or trepanning type, and a center-cut type. Both operate at unusually high speeds and low feeds to reduce axial thrust and curb deflections. Horizontal drilling simplifies chip removal. The h-p, filtered-coolant system which ejects chips through the open V in the drill shank, also removes heat and lubricates wear pads that guide the drill.

Outboard bearings are used to support the drill at the work face. Manual controls position the drill to within 0.003 in. and automatically lock it in place by hydraulic means. Preset feeds and speeds control the forward motion through an automatic cycle that ends with automatic retraction of the drill. Any pattern of holes is drilled within a 6-ft square by moving the drill head and supporting column.

Two years of production experience at Griscom-Russell indicate that the average runout with the new machines is less than 0.002 in. per ft of hole depth for a $^{3}/_{6}$-in-diam hole. Conventional twist drills had previously averaged about 0.030 in. per ft with peaks of 0.075 in. per ft on similar production. Surface finishes are held to 15 microin.

It is possible to drill through multiple-layered stacks of thinner tube sheets and tube-support plates.

Better alignment is produced of tube holes in baffles, support plates, and tube sheets in the manufacture of l-p heat exchangers.

Insulating Refractories

INSULATING REFRACTORIES play an important part in Lindberg Steel Treating Company's new gantry-type controlled-atmosphere hardening furnace with atmosphere quench at the Melrose Park plant near Chicago, Ill. The furnace is electrically heated, has five control zones, operates between 250 and 2050 F, and rolls on wheels along tracks that straddle a large pit. It is both bottom-loading and bottom-quenching. The pit, which is 19 ft wide × 28 ft deep × 55 ft long, houses the loading station, atmosphere-quench tank, salt-quench tank, and water-wash tank. A 6000-cu-ft per-hr endothermic gas generator supplies atmosphere gas to the hardening furnace. The hardening furnace and associated equipment can accommodate a loading fixture with an effective work load of 80 in. in diam × 288 in. in length.

Insulating fire brick is used to help keep temperatures constant by reducing heat loss. The brick used is Armstrong Cork Company's type A-25 which has a maximum hot-face temperature of 2500 F. A-25 has a modulus of rupture of 110 psi, compressive strength of 225 psi, pyrometer cone equivalent is 29, and the corresponding softening point 3018 F.

The brick is formulated to balance insulating efficiency with high strength. Selected refractory clays blended with particles of carefully graded burnout material are used. When the bricks are fired, the burnout is consumed, leaving in the brick structure the scientifically sized air spaces that give these bricks their high insulating value.

Close control of combustion when the bricks are fired eliminates internal strains and gives the bricks a uniform structure throughout. The high strength that results greatly lengthens the life of the bricks. They withstand mechanical abuse, offer great resistance to wear and to erosion by high-velocity gases and flame impingement, have good load-bearing properties, and permit sound wall construction.

They resist spalling, and the fine-grained, dust-free surface allows mortar to key securely for a strong bond. At 1200-F mean temperature, A-25 Insulating Fire Bricks have conductivity of 2.4 Btu per sq ft-hr-deg F per in.

Big Chip. A $6^{3}/_{8}$-in-long chip made with a 3-in. high-speed steel twist drill, driven at 0.100-in. feed in mild steel by a Giddings & Lewis redesigned Chipmaster radial drill

PHOTO BRIEFS

1 Hydrofoil Landing Craft. Retractable hydrofoils permit an adapted amphibious landing craft to skim along above the water at speeds up to 50 mph or travel on land. Ordinary amphibious craft travels at 6 mph in water. The "Flying Duck" developed by Avco Corporation's Lycoming Division is powered with an 860-hp Lycoming T 53 aircraft gas turbine. The three hydrofoils—two forward, one at rear—begin to lift the vehicle out of the water when speed reaches 5 mph. It is well out at 13 mph, and 4 ft above the surface in full "flight." An automatic pilot senses waves ahead and controls the foils to maintain level high-speed flight in seas with 4-ft waves. It can negotiate rough seas as well, and among many other applications can be launched from a "mother" ship 100 miles at sea to make a beachhead in 2 hr.

2 Mobile Missile. A launching car developed by ACF Industries, Inc., and American Machine & Foundry Company would permit launching of intermediate-range and intercontinental ballistic missiles from any point on the $^{1}/_{4}$-million-mile U. S. railroad network.

3 Controllable-Pitch Propeller. A new type of balanced-load controllable-pitch propeller in diameters up to 28 ft, patented by Baldwin-Lima-Hamilton Corporation, is adaptable to commercial vessels. The reversible 4-blade 9-ft-9-in-diam prototype, shown here, has been declassified after a 2-yr test.

4 Giant Positioner. A positioner with a capacity of 200,000 lb at 24-in. center of gravity and 24-in. eccentricity made by Worthington Corporation is being used by Bucyrus Erie in producing large steam shovels.

5 Wing Attachment. Fuselage diameter has been narrowed 12 in., weight cut substantially, and fuselage space saved by using a high-strength closed-die aluminum forging. Rather than extend the bulky wing structure through the plane, wings of the Lockheed Jet Star are bolted directly to five of these forgings at their juncture with the fuselage skin.

6 Flame-Cutting Table. Widely spaced cast-iron cones dissipate the heat of gas-torch flame cutting and provide air space between the plate and table. The high cost of repairing or replacing tables is eliminated. Cleveland Crane & Engineering Company, Wickliffe, Ohio, makes them in standard sizes which can be fastened together to obtain larger areas.

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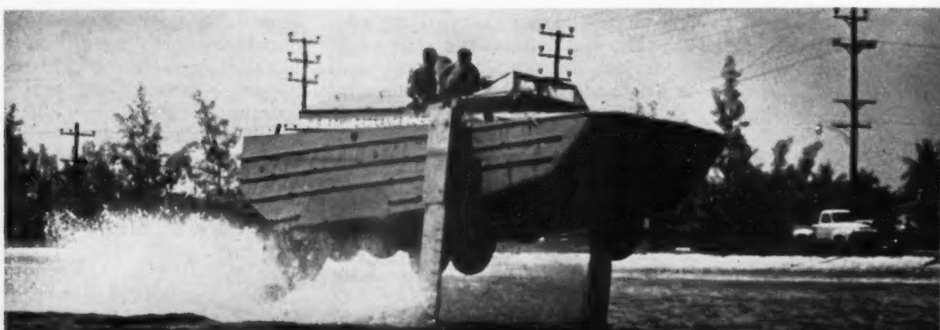

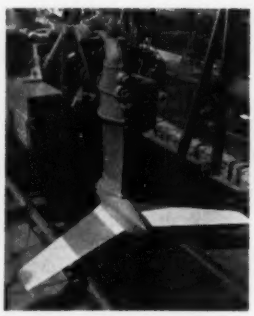

Mass-Produced Transistors. Directly usable germanium dendrites—thin, flat, continuous strips—are now grown at Westinghouse laboratories. Semiconductor devices can be constructed directly on the surface, cut apart, and encapsulated. Eventually this can be done automatically at high speed and with high reliability.

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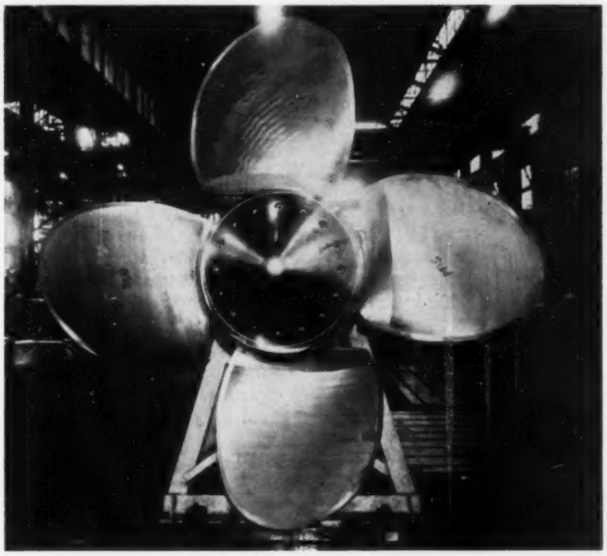

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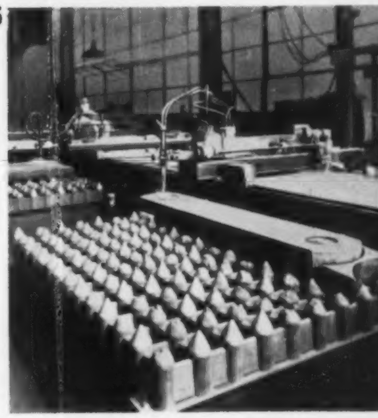


Engineering Progress in the British Isles and Western Europe

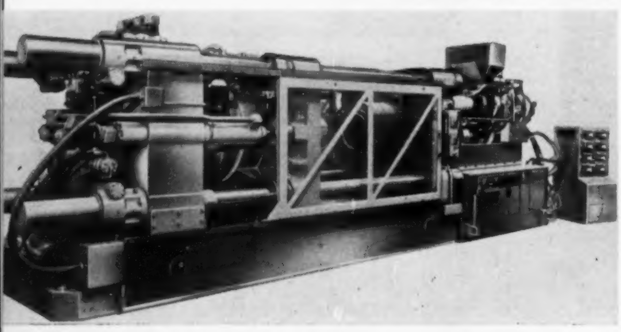
J. FOSTER PETREE
European Correspondent

EUROPEAN SURVEY

Automatic Injection Molding Machine

One of the most prominent exhibits at the recent International Plastics Exhibition held in London, England, was the AP200 injection molding machine of R. H. Windsor Ltd., Chessington, Surrey, which was shown there for the first time. Capable of taking molds up to 51 in. × $33^1/_4$ in., and of applying a locking force of 800 tons, it has maximum shot ratings ranging from 107 oz with polyethylene to 153 oz with cellulose acetate, and a plasticizing capacity (based on the continuous rating of the preplasticizing unit) of 350 lb/hr with polystyrene. The diam of the injection plunger is 4 in., the stroke is 17 in. (at a speed of 325 in./min), and the total load on the plunger is 157,100 lb. The time for a complete injection stroke is 3 sec. The four tie bars, of $6^1/_2$-in. diam, are spaced at 40-in. centers vertically and horizontally. Molds can be accommodated with a minimum combined thickness of 12 in. and a maximum of 32 in. The maximum daylight is 68 in. A vertical mold adjustment of 20 in. is provided and is effected hydraulically. The total heating capacity is 36 kw. There are three pumps, all of the Vickers-Armstrongs V. S. G. type, two delivering 96 gal/min at 2000 psi (combined) and the third 16 gal/min at 3000 psi. The over-all dimensions are 28 ft × 5 ft 4 in., and the machine weighs approximately 36 tons. It is fitted with the makers' twin-screw "Autoplas" preplasticizer.

Automatic injection molding machine, AP200, is capable of molding articles up to 124 oz in polystyrene. R. H. Windsor Ltd., is the manufacturer.



New Works and Research Center for Utility

The English Electric Company have chosen a historic site for the new Atomic Research Center, designed to serve the English Electric–Babcock & Wilcox–Taylor Woodrow consortium which is engaged at present in constructing the 500-mw nuclear power plant at Hinkley Point, England; for this new establishment, which was declared open on July 24 by Lord Mills, the British Minister of Power, has grown out of and around the small works at Whetstone, near Leicester, originally occupied in 1942 by Power Jets (R. and D.) Ltd., the organization created to continue and extend the initial development work of Sir Frank Whittle on jet propulsion of aircraft. Many of the early turbojet engines for wartime high-speed aircraft were made there. The English Electric Company are now concentrating there the divisions for gas turbines and small steam turbines. Manufacture of gas turbines is partly carried out at the Company's works at Rugby and elsewhere according to the size of the plant and the facilities consequently required—two sets recently installed at the Royal Aircraft Establishment at Bedford are of 20,000 kw each and are the largest yet put into service in the United Kingdom. The small steam turbine section of the Steam Turbine Division (that is, the part which is at Whetstone) deals with the design, development, and production of small geared units up to 5000 kw and covers the complete field of condensing, back-pressure and pass-out turbines for industrial purposes.

The Mechanical Engineering Laboratories which Lord Mills inaugurated cover some 37,000 sq ft and are laid out to undertake long-term research and development work for a number of the product divisions of the Company and also to deal with sponsored research on specialized subjects. The work carried on falls into the four main groups of mechanics of solids, mechanics of fluids, heat, and mathematics. Features of the equipment of particular note are the graphite machine shop, a pit 85 ft deep for testing charging machines for reactors, the toxic laboratories for experimental work with uranium and beryllium, and the range of computers.

Prominent among the guests at the opening was Dr. Louis Werner, representative in the U. K. of the United States Atomic Energy Commission. Also present at the official opening were: J. V. Dunworth, P. W. Mummery, and H. S. Arms, leading executives of the English Electric Company, Atomic Power Division.

Correspondence with Mr. Petree should be addressed to 36 Mayfield Road, Sutton, Surrey, England.

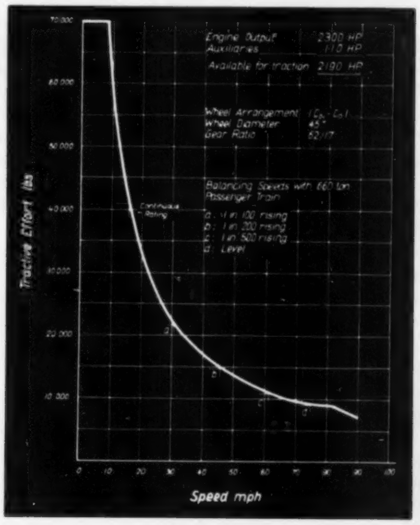
Diesel-Electrics for British Railways

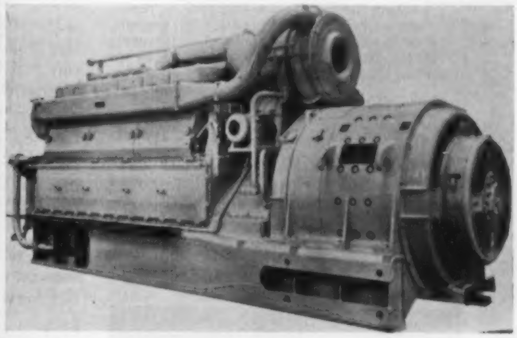
British Railways are now bringing into service a new class of diesel-electric locomotives for main-line express trains. Designed for a maximum speed of 90 mph, they are fitted with Sulzer "twin" four-stroke diesel engines having 12 cylinders arranged side by side in two rows of six, each bank of six cylinders having its own crankshaft driving onto a common output shaft through straight spur gearing. The number of these locomotives on order is 147 and all are being built in the shops of British Railways at Crewe and Derby. The diesel engines for the first batch of ten are being supplied by Sulzer Brothers, of Winterthur, Switzerland, but the engines for the remaining 137 are being built under license by Vickers-Armstrongs (Engineers) Ltd., at Barrow-in-Furness, England.

The Sulzer engine fitted has a power output of 2300 hp at 750 rpm and drives a ten-pole self-ventilated generator of 1531 kw continuous rating at 1080 rpm through a step-up gear. The Crompton-Parkinson generator is coupled to the synchronizing pinion of the diesel engine and is mounted on an extension of the engine framing. The six traction motors are series-wound and force-ventilated by two motor-driven blowers, each supplying 6750 cfm to three motors. The motors are axle-hung and have a continuous rating of 305 hp at 440 amp and 580 v.

The brake equipment also is of Swiss design, being of the Oerlikon type, but is manufactured in Manchester, England, by Davies & Metcalfe Ltd. Brake blocks are fitted on both sides of each driving wheel, and each block has its own individual brake cylinder. This brake system is of the pressure type, but an automatic vacuum brake is also fitted and the control of this operates the vacuum brakes on the train. The air brake on the locomotive is automatically applied in proportion to, and in synchronism with, the vacuum brake on the train, and is released in proportion to the vacuum in the train pipe.

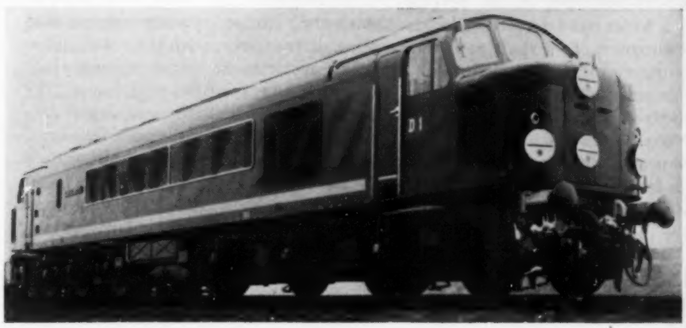
Diesel-electric locomotive performance characteristic. Engine has power output of 2300 hp at 750 rpm.

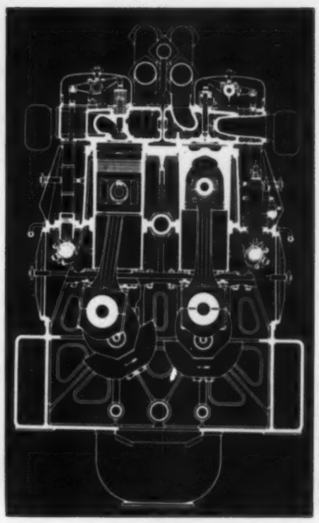




Sulzer "twin" four-stroke diesel-engine drives a ten-pole self-ventilated Crompton Parkinson generator of 1531 kw continuous rating at 1080 rpm

British Railways new class of diesel-electric locomotive is one of 147 on order for main-line express service. Trains have maximum speed of 90 mph.





Cross section of Sulzer 12 LDA28 engine. Twelve cylinders are arranged side by side in two rows of six.

The locomotives have the 1-C-C-1 wheel arrangement and weigh rather more than 138 tons in working order, giving an axle loading of 19 tons 2 cwt. The maximum tractive effort is 70,000 lb, and they can exert a continuous tractive effort of 41,000 lb at $16^1/_2$ mph. The driving wheels have a diam of 3 ft 9 in. The over-all length of the locomotive is 67 ft 11 in., and they can work round curves of a minimum radius of 330 ft.

Substance in Brief of Papers Presented at ASME Meetings

M. ZANFARDINO
Staff Editor

ASME TECHNICAL DIGEST

Machine Design

Pressure-Actuated Cylindrical Diaphragm Seals..59—SA-1... By C. Y. Neou, University of Bridgeport, Bridgeport, Conn. 1959 ASME Semi-Annual Meeting paper (multilithographed; available to April 1, 1960).

Control valves for regulating flow of fluid should provide tight sealing against leakage or loss of pressure when fully closed on the one hand, and noninterfered opening and closing on the other. For large-size pipelines, wind and water tunnels, and so on, butterfly valves with rubber-lined seats are often employed for their simplicity and compactness. While providing tight sealing, a rubber-lined butterfly valve requires an unusually large, often unpredictable, operating torque for seating and unseating. In addition, rubber and plastics cannot stand high temperatures and are subject to various chemical corrosion and oxidation.

To meet the two seemingly conflicting demands of tight closure and noninterfered operation, a pressure-actuated movable metallic sealing seat may be used in place of a fixed elastic seat. A thin-walled cylindrical sealing band is butt-welded peripherally onto the inside of a valve body. Introduction of compressed air or any other fluid under pressure through a hole in the valve body into a small recess or pressure chamber between the valve body and the sealing band causes the latter to expand inwardly until it firmly closes the clearance between the band and the edge of the valve disk in the fully closed position. The flexible seal not only provides an adjustable snug-fit closure in a wide range of temperature variations, thus permitting ample tolerance in manufacturing, but also serves as a relief valve giving a vent to any excessive pressure rise in the line after the valve is closed and sealed.

Among numerous materials suitable for making the sealing band, nickel alloys, such as Inconel-X, are among the most popular, mainly because of their unusually high strength and elasticity at all temperatures—subzero to 1500 F or higher—excellent resistance to chemical corrosion and oxidation, and low creep rate under high stress at high temperature. Although a metal-to-metal seal is normally not bubble-tight, the sealing edge of the disk is usually fitted with bronze, stainless-steel inserts, chrome-plated, or glass-coated when the valve handles fluid under high pressure at extremely high (to 2000 F) or low temperature (to −400 F) or a highly corrosive fluid; otherwise rubber or plastic inserts may be used to make better sealing contact between the band and the edge of the disk.

The presence of a moving band between the valve body and the valve disk necessarily demands a relocation of the valve shaft and its bearings. Instead of running diametrically through the valve disk in its plane, the shaft is inclined out of the plane of the valve disk and supported in offset bearings clear of the sealing band. As a wider band demands a larger angle of inclination of the shaft, resulting in more protrusion of the shaft into the flow area in wide-open position, a short band is always preferred if it can seal the clearance with a reasonably low actuation pressure and without causing damaging stresses in it.

Analytic formulas and charts are developed for the rational designing of the thin-walled metallic cylindrical shell or band welded peripherally onto the inside of a valve body.

Dynamic Analysis of a Cylindrical Cam.. 59—SA-3... By R. J. Fanella, Assoc. Mem. ASME, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill. 1959 ASME Semi-Annual Meeting paper (multilithographed; available to April 1, 1960).

Cylindrical or drum cams have been used extensively in machinery in the past, second in popularity only to the radial-disk cam. Improved machining techniques and the ever-increasing use of automatic machinery have warranted the even wider use of cylindrical cams.

This type of cam finds use where linear motion is required from a power source having simple rotary motion. This paper develops the dynamic force and torque relationships for a cylindrical cam and its associated follower.

The cylindrical cam configuration consists of a driven rotor in which the cam follower is restrained to travel in the longitudinal track in the rotor. Surrounding the rotor and cam follower is the cam path cut within a stationary cylinder. This type of cam finds use as a pickup and delivery mechanism; i.e., it may be the mechanism used to feed another machine. Parts are picked up by the follower and driven forward to a second station where they are delivered. The follower then returns to repeat the pickup-delivery cycle. The more common cylindrical cam utilizes a rotating cam with a translating follower.

Mechanism operation is considered with the rotor at constant velocity and also, alternatively, with the rotor undergoing acceleration. It is shown that, for operation at constant velocity, the use of the equations for torque and cam normal force is well ordered. However, with the rotor accelerating, the procedure used in obtaining a solution to a particular problem is even more dependent upon the physical parameters involved.

Slight modification of this analysis will allow its use for a translational cam in which the cam follower slides in a straight slot in a body undergoing translation while the follower roller is within a cam path cut in a fixed flat plate.

Dynamic force and torque relationships are developed for a cam follower restrained within a moving rotor and actuated by a cylindrical cam. Mechanism operation is considered with the rotor having a constant angular velocity and also undergoing angular acceleration. The method used to find torques and cam loads for actual problems is outlined and an example is given.

A Mechanical Time-Delay Device Sensitive to Centrifugal Fields..59—SA-9... By J. R. Baumgarten, Purdue University, Lafayette, Ind.; R. Cohen, Assoc. Mem. ASME, Whirlpool Corporation Research Laboratory, St. Joseph, Mich.; and A. S. Hall, Jr., Mem. ASME, Purdue University, Lafayette, Ind. 1959 ASME Semi-Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.**; available to April 1, 1960).

Time-delay devices have wide usage in industrial and military applications. The most common device used in timing events in a mechanical or electrical system is an electronic time-delay circuit. There are applications in the control field where electrical power is either not available or must be used for other purposes. Mechanical power is usually available in industrial applications in the form of shaft power and is often available in missile and other ballistic applications in the form of a rotating casing. In addition to the unavailability of electric power, a mechanical device may be chosen over the electrical device because of the possibility that a particular design will be less expensive, easier to fabricate, and more rugged and reliable than the corresponding electrical one.

This paper presents a device which does not require electrical power. This device derives its power from a centrifugal field.

Static and Dynamic Behavior of Flexible Torsional Couplings With Nonlinear Characteristics..59—SA-8... By A. Seireg, The Falk Corporation, Milwaukee, Wis. 1959 ASME Semi-Annual Meeting paper (multilithographed; available to April 1, 1960).

Flexible couplings are frequently used in mechanical drives to improve the dynamic qualities of the system and to provide protection against hazardous transients or high vibratory stresses. The most important characteristics of a flexible coupling are the elastic constant and damping capacity. These characteristics may be linear or deviate from linearity according to the coupling design and range of load application. The elastic properties are linear when the rate of change of torque with respect to twist is constant. The damping is considered linear if it is of viscous nature.

The basic advantage of a flexible coupling is the ability to provide the maximum possible elasticity under a certain load within a limited space. Furthermore, it should be able to withstand some momentary increase in load without failure. Couplings with nonlinear elastic characteristics satisfy these requirements because they can be designed with relatively low stiffness under normal loads and with simultaneously increasing stiffness and strength under increasing loads. This characteristic is very desirable for a shock-absorbing element.

Dynamic systems having components with nonlinear characteristics are difficult to analyze. The problem can be simplified considerably by using equivalent linear factors to replace the nonlinear coefficients for a particular range of operation. It is due to the work of Rauscher, Den Hartog, K. Klotter, and others in this field that approximate solutions could be obtained for nonlinear systems which are sufficiently accurate for many purposes.

The load-deflection relationship for a flexible coupling is usually defined by an experimental hysteresis loop rather than a simple mathematical curve. It is of interest to provide a procedure by which the dynamic performance of the coupling under various cycles of load can be predicted from these hysteresis loops.

A Falk Steelflex coupling is studied in this paper. The elastic member is a continuous steel grid supported by curved teeth on both hubs. The characteristics of the coupling are determined by the construction details of the grid member and the hub teeth. The coupling is packed with grease and is contained in a sealed floating cover.

The Automobile Engine as a Dynamic Vibration Absorber..59—SA-10... By J. A. Carlson, Teletype Corporation, Chicago, Ill. 1959 ASME Semi-Annual Meeting paper (multilithographed; available to April 1, 1960).

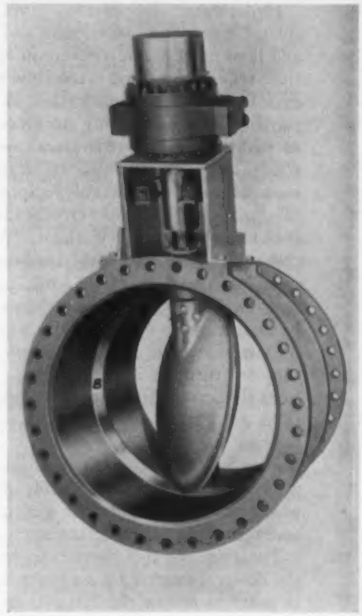
In all fields of engineering, modern computational techniques have extended the usefulness of mathematical analysis in design. This paper presents an example of how an analytical study can solve a design problem and clarify the behavior of a complicated mechanical system.

It is shown that the automobile-engine mass on its flexible mountings can be used as a dynamic vibration absorber to reduce shake of the vehicle frame caused by a mode of vibration of the car wheels on the tires known as wheel bounce. The conclusion is reached that the same analytical techniques could be used to study the absorption of other modes of vibration by the engine, as well as many other vibration problems in vehicles.

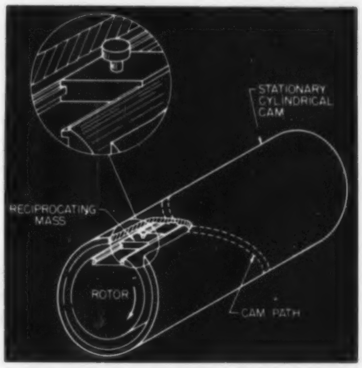
Flow Parameters in Hydrostatic Lubrication for Several Bearing Shapes..59—SA-61... By S. Raynor, Mem. ASME, and A. Charnes, Northwestern University, Evanston, Ill. 1959 ASME Semi-Annual Meeting paper (multilithographed; to be published in **Trans. ASME—J. Engng. for Indus.**; available to April 1, 1960)

Hydrostatic lubrication is the maintenance of an oil film between two stationary surfaces by pressure produced by an external pump. It differs from hydrodynamic lubrication where the oil

36-in. W. S. Rockwell butterfly valve having inclined valve shaft "A" clear of sealing band "B" (59—SA-1)



Schematic drawing of reciprocating follower surrounded by a cylindrical cam (59—SA-3)



Steelflex coupling whose elastic member is a continuous steel grid supported by curved teeth on both hubs (59—SA-8)

film is produced by the relative motion of two surfaces.

Hydrostatic lubrication gives considerable reduction of friction and wear, and is of practical importance in applications when the motion is too slow to produce hydrodynamic lubrication, as in the starting of heavy rotating machinery such as turbines, motor-generators, synchro-condensers. Hydrostatic lubrication is used also in reversal of reciprocating motion, as in pistons, crossheads, and the like. Elementary theory permits computation of the total load-carrying capacity, the flow rate of oil, pressure and velocity distribution for the so-called hydrostatic step-bearing, which consists of two circular disks, the oil being supplied through a central hole. Aside from this case, the elementary considerations no longer suffice. Recourse must be had to study and solution of the Navier-Stokes equations in suitable approximation. As will be made clear, it was possible to reduce the general case to determining a conformal mapping.

The object of this paper is to compute the flow parameters for several new cases in order to permit the designer to better approximate his own configuration by solved cases.

The designs investigated are: (*a*) Circular plates with central hole; (*b*) square plates with central hole; (*c*) elliptical plates with oil groove; and (*d*) infinite strip with central hole.

A Quantitative Investigation of the Factors Which Influence the Fatigue Life of a V-Belt..59—SA-18...By S. M. Marco, Assoc. Mem. ASME, W. L. Starkey, Assoc. Mem ASME, and K. G. Hornung, Assoc. Mem. ASME, The Dayton Rubber Company, Dayton, Ohio. 1959 ASME Semi-Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.;** available to April 1, 1960).

A V-belt is a machine member designed to transmit power from a driving pulley to a driven pulley. As in the case of most designs, the design of a V-belt drive is necessarily a compromise among the variables of cost, size, performance, and life.

The designer usually is confronted with the problem of selecting a V-belt drive which will fit into the available space and transmit the necessary power at the desired speed ratio with a reasonable life.

A new design method for V-belts has been developed. The new method involves a horsepower-life relationship which has been derived on the basis of the results of a vast experimental program of belt testing involving many hundreds of tests, together with an analysis of these data which introduces several new concepts of stress analysis for rubber-textile structures.

The Effect of Presetting Helical Compression Springs..59—SA-12...By T. J. Atterbury, Assoc. Mem. ASME, Battelle Memorial Institute, Columbus, Ohio; and W. B. Diboll, Jr., Mem. ASME, Washington University, St. Louis, Mo. 1959 ASME Semi-Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.;** available to April 1, 1960).

In this study the application of the principle of cold presetting was made to round-wire helical compression springs. Presetting was accomplished by loading the spring between parallel plates until yielding produced permanent set in the spring.

The primary purpose of the investigation was to develop a method which can be used by designers to predict the increase in resistance to fatigue of springs due to presetting, for specific design applications. The application of this method was applied to a particular material in a typical design situation and resistance to fatigue was compared with that predicted.

Petroleum Mechanical Engineering

A New Design Concept for High-Horsepower Reciprocating Pumps..59—Pet-11...By C. H. Rose, BJ Service, Inc., Long Beach, Calif. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; available to July 1, 1960).

Mobile oil-well-service pumping units supply to the wellhead a variety of fluids such as acids, cement slurries, and other mixtures of solid particles and liquids. Each truck or trailer unit mounts one or more high-horsepower internal-combustion engines which drive triplex pumps through either automotive-type transmissions or torque converters, permitting fluid delivery at various combinations of pressures and flow rates. Pressures at low flow rates may be as high as 15,000 psi; flow rates supplied to the wellhead at low pressures by two or more pumping units may exceed 100 bbl per min. The pumps typically weigh 5000 to 9000 lb each and represent more than one quarter of both the cost and legal weight of the pumping unit.

To meet increased hydraulic-power requirements, service companies have recently increased total pump input horsepower of the units to a maximum of about 1200. This was accomplished in part by increasing gross vehicle weight, often using five-axle tractor-trailer combinations to remain legal, and in part by emphasizing low weight in the design.

Twelve-hundred input pump horsepower produces approximately 1000 hydraulic horsepower. To increase pumping-unit hydraulic capacity beyond the 1000-hp level, a major improvement of at least one component was sought. Basic studies of reciprocating-pump mechanics were undertaken, which culminated in the design of a pump with one half the plunger displacement of contemporary pumps and capable of 50 per cent greater output. The studies and their experimental verfication are described briefly.

An Analytical Study of Drill-String Vibration..59—Pet-15...By J. J. Bailey, Shell Development Company, Houston, Texas; and I. Finnie, Assoc. Mem. ASME, Shell Development Company, Emeryville, Calif. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; to be published in **Trans. ASME—J. Engng. for Indus.;** available to July 1, 1960).

In almost any investigation of vibrations in drill strings, it is necessary to consider their natural frequencies. The calculation of these frequencies may not be intrinsically difficult, depending on the assumptions made, but for any but the simplest drill-string configurations it is generally very tedious. In this work, a quick method of making these calculations is demonstrated, and the effects of some parameters on the natural frequencies are considered.

The drill string considered consists of drill collars of one or more different sizes and of drill pipe. The string rests on the bit at the bottom of the hole and hangs from the traveling block at the top. The boundary conditions that result at the ends of the string are important in the calculations, but they are not at all well understood at present. The effects of any driving or damping of the vibrations that may occur in practice are neglected. Furthermore, only longitudinal and torsional vibrations of the string are considered. Lateral motions of the string (due to bending, buckling, whirling, whipping, and so on) are neglected, and it is assumed that the torsional and longitudinal motions considered are independent.

An Experimental Study of Drill-String Vibration..59—Pet-16...By J. J. Bailey, Shell Development Company, Houston, Texas; and I. Finnie, Assoc. Mem. ASME, Shell Development Company, Emeryville, Calif. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; to be published in **Trans. ASME—J. Engng. for Indus.;** available to July 1, 1960).

Reasonable correlation with experimental results is obtained. For the cyclic load conditions and the material chosen, an increase in load-carrying capacity of 21 per cent was observed. It is expected that an increase of approximately 40 per cent could be realized with slight modification of fabrication techniques.

Nomographic Synthesis of Generator Linkages..59—SA-11...By D. P. Adams, Massachusetts Institute of Technology, Cambridge, Mass. 1959 ASME Semi-Annual Meeting paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.**; available to April 1, 1960).

Machines are doing more complex jobs; the need grows for simple operation and low cost of parts. The generator, or computer, linkage often fills this bill if technical requirements can be met by good methods for practical design.

This article presents a graphical technique for optimizing generator-linkage design by systematic scanning of five linkage parameters. A nomograph of linkage behavior, simplified through symmetry of quadrilateral relationships, fixes the optimum linkage as a rectilinear, horizontal plot from which a measure of the error is available.

. . . .

Equipment is described which has been developed for the measurement of axial force, torque, and axial and rotational motions at the top of a drill string.

Measurements made in two wells with this equipment represent the first time these quantities have been recorded during drilling.

A large number of frequencies of vibration were found in the recordings. Some of these, particularly torsional readings, correlated with predicted natural frequencies, but many did not.

Several explanations have been proposed for these "extraneous" frequencies, but no completely satisfactory solution is available.

In addition, some interesting interrelations between axial and torsional vibrations were observed.

Two-Stage Centrifugal Pipeline Compressor..59—Pet-20...By E. W. Tanzberger, Mem. ASME, and H. O. Jacobi, Clark Brothers Company, Olean, N. Y. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; available to July 1, 1960).

From an initially low compression ratio of about 1.10 per impeller, centrifugal pipeline compressors have now been designed with a ratio of greater than 1.50.

An ever-increasing compression ratio per single impeller becomes undesirable, based on certain fundamental considerations such as specific speed (with its relationship to hydraulic design and efficiency), slope of the characteristic curve, stability, and internal gas-friction losses.

A suitable solution may be the operation of several single-stage units in series or the application of a single-casing multistage compressor.

A number of two-stage, high-pressure compressors have been built by the authors' company. The various design considerations, both from a hydraulic and mechanical viewpoint, together with the expandability from high-head low-flow to low-head high-flow operation are discussed for this specific application.

Methods of Displacement in Multiple-Tubing String Wells..59—Pet-24...By W. W. Word, The National Supply Company, Houston, Texas. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; available to July 1, 1960).

Multistring completions are no novelty in the oil fields of the world. The motivating force behind the multistring trend is economics. The upward spiral of exploration, drilling, production, and marketing costs has necessitated employing the most efficient and most economical depletion methods. There is no possibility in the foreseeable future that the multistring trend will be reversed. On the contrary, it is expected that, percentagewise, the number of new multistring wells will increase substantially and a large number of existing wells with a single producing zone will be recompleted as multiple producers with two or more tubing strings to save the cost of drilling another well. New equipment and new completion techniques have been developed which provide flexibility, economy, and safety during operations. It is anticipated that future advances in equipment design will even further accelerate the growth of multiple-tubing string wells.

Because of the multiplicity of applications, most manufacturers of completion equipment have been required to design an infinite number of special purpose products, all of which fall into the general category of multistring equipment. Regardless of the particular requirements, operators have insisted that the equipment for multiple-string completions offer the same measure of protection which is available for single-string installations.

Because of the rapid evolution of completions of this type, it is the aim of this paper to summarize various completion practices which are currently in use and to comment briefly on some equipment which is unique to multiple-tubing string wells. It is further intended to discuss certain trends in multistring operations which, in the opinion of the author, will tend to offset the economic advantages of this type of completion.

Flow Equation for Gas Transmission Pipelines..59—Pet-22...By E. Gordon, United Gas Pipe Line Company, Shreveport, La. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; available to July 1, 1960).

In modern transmission systems, natural gas is compressed sufficiently to cause it to deviate significantly from ideal gas behavior. Furthermore, transmission systems are subject to frequent variations in the gas flow rate.

Owing to the very slow response of the system to these changes from the macroscopic point of view, other changes usually occur long before the effect of a previous change disappears. Because of these factors, there is a need for a flow equation which adequately and conveniently allows for the gas nonideality and which is valid in the presence of the inevitable slow transients.

This paper presents a flow equation which is efficient for both digital and analog computers and is derived in a manner valid for a nonideal gas flowing in a pipeline subject to slow transients. If manual flow computations are necessary, appropriate tables can be constructed to make this flow equation convenient for the gas compositions usually handled at the temperatures of greatest importance with regard to pipeline flow.

Structural Verification of Pressure Equipment..59—Pet-29...By G. P. Eschenbrenner, Mem. ASME, and C. A. Honigsberg, Assoc. Mem. ASME, The M. W. Kellogg Company, New York, N. Y. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; available to July 1, 1960).

Pressure testing of pressure equipment such as vessels, exchangers, and piping after fabrication is a practice of long standing and is required by applicable current codes. As a result, pressure testing has been widely accepted as proof that components which satisfactorily pass such tests are suitably designed and fabricated for service at the design conditions.

Many actual failures of pressure equipment have occurred, however, as the result of structural weaknesses or other conditions which cannot be evaluated or detected by a pressure test. Therefore the reliability of such tests as a criterion of suitability for service is seriously open to question.

This paper is primarily concerned with

a rational evaluation of structural verification, i.e., with requirements for inspection and testing consistent with the intended service of the pressure equipment and the design basis utilized.

It has been emphasized that structural verification is an intimate and inseparable part of the total approach to effective pressure-vessel construction, and that pressure vessels which neither overemphasize nor neglect any aspect can be attained only by a logical and balanced association of design approach, material quality, fabrication refinement, and extent of inspection.

Each of these is related to structural verification so that practical assurance of structural capabilities is obtained which is consistent with the general class of construction involved.

Simplified Approach to Understanding the Suction Problems for Reciprocating Mud Pumps..59—Pet-23...By W. E. Liljestrand, Mission Manufacturing Company, Houston, Texas. 1959 ASME Petroleum Mechanical Engineering Conference paper (multilithographed; available to July 1, 1960).

Design of mud-pump suction systems has apparently been done empirically or by experience. The results have been reasonably satisfactory, but many instances of trouble have raised questions about the corrections needed. Standards have not been prepared and distributed.

Increased competition in drilling, however, requires that pumping costs be kept as low as possible and that all pumps perform at maximum output and efficiency.

A good understanding of the mud-pump suction problem applied to suction systems can give the following advantages:

1 Less replacement of fluid-end parts.
2 Longer life of power-end drive system.
3 Increased pump capacity.
4 More dependability of pump under adverse conditions.
5 Possibly less costly suction-piping system.
6 Less concern and worry by the crew.
7 Effective use of suction dampeners and prechargers.

This paper analyzes pump-suction and suction-piping characteristics showing responsibility areas of users and manufacturers. Empirical formulas and verifying test procedures are explained. This material should be used as a basis for preparation of standards on pump-suction systems as used in the oil field. It will reduce pumping troubles and costs and permit increased pump output.

Overstrain Tests on Thick-Walled Cylinders..59—Pet-1...By S. M. Jorgensen, Foster Wheeler Corporation, New York, N. Y. 1959 ASME Petroleum Mechanical Engineering Conference paper (in type; to be published in **Trans. ASME—J. Engng. for Indus.**; available to July 1, 1960).

Experimental work described in this paper covers pressure-expansion tests on thick-walled, closed-end cylinders of four different steels.

The tests covered stress levels through the plastic and strain-hardening ranges to destruction, at pressures up to 100,000 psi.

A theoretical method is given for computing expansion and bursting strength, based on both tension and torsion data.

Finally, a simplified formula for ultimate pressures is described and checked against the experimental data.

Heat Transfer

Radiant Interchange Within an Enclosure..59—HT-4...By J. T. Bevans, Mem. ASME, Shell Development Company, Emeryville, Calif.; and R. V. Dunkle, University of California, Berkeley, Calif. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer**; available to June 1, 1960).

This is the first of three papers relating to a general analysis of the radiant interchange within an enclosure filled with an absorbing and emitting medium, i.e., combustion products. The problem is approached initially by reviewing the basic physics of the absorption (or emission) of thermal radiation by gases (Part 1). The band approximations of Elsasser are examined and compared with the experimental results of Howard, et al. The inapplicability of the exponential absorption law on a band energy or total energy basis is briefly discussed and the deviations from experiment pointed out. As an engineering approximation to the use of a monochromatic energy analysis, the absorption of gases on the band energy basis is incorporated in the geometrical interchange relationships between two surfaces.

In Part 2, the network method of Oppenheim is used to derive the basic network relationships between one node and the other nodes of an enclosure. This is first done on a monochromatic basis and then reduced to the band energy approximation using the results of Part 1. The usual method of analysis, the gray radiation approximation, is shown to follow from the band energy and to be generally an approximation of lesser accuracy. A reiterative method of solving the network node equations for as many nodes as deemed practicable is presented in Part 3 and specific solutions are given as examples. These examples are used to illustrate the relative accuracies of the band energy and the gray radiation approximations.

In order to obtain a solution of the enclosure problem, a number of assumptions have been required. These assumptions were necessitated by the inadequacy of present knowledge. Also, sufficient information does not exist regarding the radiative characteristics of most enclosures. These gaps in analytical and physical knowledge are indicated and are promising areas for both theoretical and experimental study.

Refractory Metal Thermocouples..59—HT-21...By J. C. Lachman, General Electric Company, Cincinnati, Ohio. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

The thermoelectric properties of refractory metals were studied with emphasis on the use of the element rhenium for thermocouple applications.

The pure metal combinations of rhenium versus molybdenum and rhenium versus tungsten were calibrated to 4000 F in vacuum, hydrogen, and inert-gas atmospheres. Both rhenium-molybdenum and rhenium-tungsten thermocouples have a high thermal emf which is reasonably linear with temperature. The practical application of rhenium-molybdenum is limited to about 3200 F by loss of thermoelectric potential. Rhenium-tungsten thermocouples, however, measure temperatures up to 4000 F and apparently higher.

Practical applications of these two thermocouples are discussed including availability of required materials, cost comparison with present commercial thermocouples, and outlook for future development.

Investigations of rhenium-tungsten and rhenium-molybdenum alloys are in progress aimed at the discovery of thermocouple materials with better thermoelectric and mechanical properties.

Heat Transfer to Fully Developed Laminar Flow in a Circular Tube With Arbitrary Circumferential Heat Flux..59—HT-13...By W. C. Reynolds, Assoc. Mem. ASME, Stanford University, Stanford, Calif. 1959 ASME-AIChe Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer**; available to June 1, 1960).

A solution is presented for fully developed laminar heat transfer in a circular tube with arbitrary circumferential heat flux. Examples included indicate that the influence of circumferential heat-flux variation on wall tem-

peratures can be quite significant and provide some insight into the nature of the effects. The analysis allows calculation of wall temperatures for any arbitrary peripheral heat-flux variation for fully developed laminar flow under the restriction of constant axial heat input.

The Effect of Transverse Vibrations on the Heat-Transfer Rate From a Heated Vertical Plate in Free Convection..59—HT-27 ...By A. J. Shine, Assoc. Mem. ASME, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

An interferometer study was conducted to determine the effects of transverse vibrations on the heat-transfer rate from a heated vertical plate in free convection.

The tests covered ranges of 131 to 279 F in plate temperature, 11 to 315 cps in frequency, and 0 to 0.061 in. in amplitude.

At vibration intensities (product of amplitude in inches and frequency in cps) below about 1.0 the vibrations had no effect on the heat-transfer coefficient, while above 1.0 the coefficient increased as the vibration intensity increased and attained a maximum increase of about 40 per cent at an intensity of 4.9.

Improved Lumped Parameter Method for Transient Heat Conduction..59—HT-28...By H. G. Elrod, Jr., Assoc. Mem. ASME, Nuclear Development Corporation of America, White Plains, N. Y. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

A general mathematical method is presented suitable for the "lumping" of many damped linear systems when the response function and the forcing function can be related by a convolution integral.

The method is illustrated by application to transient heat conduction in slabs and cylindrical rods.

An ordinary differential equation relating the mean temperature of these bodies to their surface temperature is derived and then applied to the solution of several problems.

Agreement with exact results is found to be excellent except for very rapid transients. Means for estimating error are provided in the paper.

Freezing of a Growing Liquid Column..59—HT-11...By G. Horvay, Mem. ASME, General Electric Research Laboratory, Schenectady, N. Y. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

The one-dimensional problem is treated in which a liquid-metal column, of the original temperature ϑ_0, is supplied with additional metal at the top, of temperature ϑ_b, at the rate v ft/min.

At the bottom of the column a heat sink of temperature ϑ_a is maintained. The case in which ϑ_a exceeds the fusion temperature is solved for v = const, both rigorously and approximately; the case in which ϑ_a is below the fusion temperature so that a freezing front sweeps upward in the column is next treated by an approximate method. The analysis may represent, for instance, the filling stage of a casting process. This analysis will be adapted to the more important continuous casting process in a succeeding paper.

Effect of Thermocouple Cavity on Heat Sink Temperature..59—HT-20...By J. V. Beck and H. Hurwicz, Assoc. Mem. ASME, AVCO Corporation, Wilmington, Mass. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

An analysis is made of problems associated with prediction of and correction for temperature disturbance created by thermocouples placed beneath a surface of a heat sink (or calorimeter) exposed to heat flux during re-entry.

Two of the important factors affecting temperature measurement are discussed: (*a*) The disturbance created by the thermocouple itself, "hot spot"; (*b*) the fact that the thermocouple has to be placed at some distance from the heat-flux surface and thus not measuring the surface temperature.

The magnitude of the surface hot spot caused by the presence of the thermocouple is determined, and optimum location of the thermocouple is found where the undisturbed surface temperature may be read with least over-all error.

One-Dimensional Quasilinear Heat Flow With Boundary Conditions Periodic in Time..59—HT-26...By D. N. Roy and J. S. Thompson, The Johns Hopkins University, Baltimore, Md. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

If thermal conductivity and specific heat are taken as linear functions of temperature, a nonlinear heat-conduction equation results. For small nonlinearities an approximate first-order analytical solution may be obtained in certain cases.

The present analysis deals with one-dimensional problems with periodic boundary conditions. Only the steady-state solution (i.e., one which is periodic in time) is considered.

Solutions are obtained for the following cases.

(*a*) Semi-infinite solid with sinusoidal boundary temperature; (*b*) thick slab with sinusoidal temperature at one boundary and constant temperature at the other; and (*c*) thick slab with prescribed heat flux (a constant term plus a sinusoidal term) at one boundary, constant temperature at the other.

The effects of the nonlinearities are discussed; they are found to be surprisingly small.

Forced Circulation Uniform Flux Burnout Studies for High-Pressure Water..59—HT-25...By S. J. Green, Mem. ASME, B. W. LeTourneau, Assoc. Mem. ASME, and M. Troy, Westinghouse Electric Corporation, Pittsburgh, Pa. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

Pressurized water-cooled and/or moderated nuclear reactors are being designed to operate with local and bulk boiling of the water at heat fluxes which approach heat-transfer burnout fluxes. Therefore a knowledge of the various parameters which affect heat-transfer burnout is required.

With this information one can confidently design reactors to operate closer to their maximum thermal limit under either normal or abnormal conditions.

An experimental program has been under way at Bettis Plant to study steady-state heat-transfer burnout under various operating conditions.

This paper summarizes progress made on this program in the area of uniform heat-flux-burnout studies.

A Variable-Density Single-Fluid Model for Two-Phase Flow With Particular Reference to Steam-Water Flow..59—HT-7...By S. G. Bankoff, Mem. ASME, Rose Polytechnic Institute, Terre Haute, Ind. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

A model is proposed for turbulent, cocurrent flow of liquid and gas or vapor through a pipe or channel, which assumes the fluid to be a single phase whose density is a function of radial position.

A void fraction radial-distribution equation, based on bubble transport, is derived but is not presently useful, since bubble radii and diffusivities are not known.

Power-law assumptions for the radial-void fraction and velocity distributions are therefore made, which lead directly to an expression for the mean void fraction as a function of the quality. The wall stress is then computed, assuming that the Blasius expression is applicable.

Good agreement with the Martinelli-Nelson correlation for steam-water void fractions and frictional pressure drops over a range of pressures from 100 to 2500 psia and void fractions from 0 to

0.80–0.85 is obtained by choosing a single value of the flow parameter K. More generally, however, K is a function of pressure, quality, amd mass velocity. As an example of the use of the first-order terms in the Taylor expansion of K about a reference condition, the wall shear-stress equation is applied to boiling-water data taken at various mass velocities. Some hitherto undiscussed factors which may affect the void-fraction and shear-stress correlations are pointed out.

Radiation Fin Effectiveness..59—HT-17...By J. G. Bartas, Assoc. Mem. ASME, and W. H. Sellers, General Electric Company, West Lynn, Mass. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

One of the requirements for a closed-cycle power plant is a heat sink. Power plants operating in the earth's atmosphere have a choice of heat sinks and and methods for using the heat sinks. However, power plants operating in space for long periods of time have one heat sink, space, and one means of transferring heat to the heat sink, a radiator. This radiator is a "true" radiator in that all heat leaving its surfaces does so by radiation. There is, apparently, no reference in the available literature which provides a rapid method for estimating the radiator effectiveness and for optimizing fin designs.

An engineering method for calculating radiation-fin effectiveness is presented in this paper. A graph which can be used to aid in design of a fin such that the heat flux is maximized for a given fin weight is also given. It is pointed out that the tube weight and tube spacing must be considered in any effort to minimize the weight of the entire radiator. These items and the effect of spacial interference by the tubes of fin radiation will be considered in a forthcoming paper.

Conductive Heat Transfer in a Re-Entry Body—Analysis of Computational Methods and Their Reliability..59—HT-23... By H. Hurwicz, Assoc. Mem. ASME, and M. S. Klamkin, AVCO Corporation, Wilmington, Mass. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

An examination of accuracy and precision of computing methods used in thermal evaluation of re-entering bodies is made, and the critical relationship existing between their thickness and surface temperature rise is shown to require extreme computational accuracy.

A study of mathematical (network subdivision) and nonmathematical factors (selection and treatment of thermo-physical properties) affecting accuracy is made.

Computational methods (digital and analog) used in re-entry calculations are discussed and preferred procedures are recommended based on comparison of various numerical and "exact" analytical methods.

Transient One-Dimensional Heat-Conduction Analysis for Heterogeneous Structures Including an Ablating Surface..59—HT-22...By M. L. Miller, Convair Division of General Dynamics Corporation, Fort Worth, Texas. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

A one-dimensional, transient heat-conduction analysis through a composite wall of different homogeneous layers in series, for variable boundary conditions has been derived for the digital computer.

The analysis can incorporate: (*a*) Temperature-dependent physical properties, (*b*) arbitrary number of homogeneous layers, and (*c*) interface with conductive, convective, and radiative heat transfer or any combination of the three modes.

The phenomenon of surface ablation is incorporated by defining a surplus temperature procedure.

This is a mathematical procedure accounting for heat absorption during melting by temperature values unrealistically above the material melting point, whereas heat transfer is computed with physically real temperatures.

Thermodynamic Properties of Helium at Low Temperatures and High Pressures..59—HT-19...By D. B. Mann, National Bureau of Standards, Boulder, Colo.; and R. B. Stewart, Mem. ASME, University of Colorado, Boulder, Colo. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in Trans. ASME—J. Heat Transfer; available to June 1, 1960.

Recent interest in compressed liquid helium has resulted in considerable new experimental data of the thermodynamic properties of helium. Investigations of liquefaction or refrigeration cycles and the design of heat-exchange equipment indicate the need for a correlation of the thermodynamic properties and their presentation in an accurate and convenient manner.

The thermodynamic properties of helium have been compiled and correlated for a temperature range from 3.0 to 20 K for pressures to 100 atmospheres and for specific volumes from 5 to 800 liters per kilogram.

The properties are presented on both the temperature-entropy and the enthalpy-entropy co-ordinate systems and include pressure, temperature, volume, entropy, and enthalpy.

Measurement of the Thermal Conductivities of Gases at High Temperatures..59—HT-2...By R. G. Vines, Commonwealth Scientific and Industrial Research Organization, Division of Industrial Chemistry, Melbourne, Australia. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in Trans. ASME—J. Heat Transfer; available to June 1, 1960).

The determination of thermal conductivities at high temperatures is unusually difficult because the large heat losses produce thermal instability in experimental equipment. Investigations previously carried out have shown that measurements above 500 C are often liable to errors of up to 20 per cent. In the work reported here a system of high thermal capacity was employed, and consistent and reproducible results were obtained. It thus seems likely that the conductivity values given are substantially correct and that reasonably accurate high temperature measurements have been achieved.

Experimental results are reported for the thermal conductivities of air, argon, nitrogen, and carbon dioxide at temperatures up to 900 C, and of steam up to 560 C. These results are compared with values predicted from correlation formulas based on low temperature measurements.

Spectral Characteristics of Fabrics From 1 to 23 Microns..59—HT-9...By R. V. Dunkle, F. Ehrenburg, University of California, Berkeley, Calif.; and J. T. Gier, University of California at Los Angeles, Calif. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in Trans. ASME—J. Heat Transfer; available to June 1, 1960).

The evaluation of the heat transfer to and from clothing requires a knowledge of the absorptance, reflectance, transmittance, and emittance of the cloth. Such information may consist of total radiant property measurements which are applicable only for specific conditions, or it may consist of spectral data which can be utilized to predict the total radiant properties for sources of any spectral distribution. This investigation was concerned with the determination of the spectral reflectance of several types of natural, synthetic, and regenerated textiles used as clothing materials.

The work described in this paper was performed at the University of California at Berkeley as an outgrowth of a research project sponsored by the United States Army Quartermaster Corps Research and Development Center. The spectral reflectance as reported here is actually the system reflectance, since, in addition to energy reflected from the sample, it also includes energy that passes through the sample and is re-

flected from the low reflectance background and transmitted back through the sample. A low reflectance background was used in these tests; as a consequence, the effect of the background was negligible except in the region of 1.0 to 3.0 microns where the textile material is relatively transparent to infrared radiation. It was found experimentally, for the materials reported in this paper, that three layers were sufficient to eliminate the effect of the background, so data were reported for both single and triple layers of cloth.

Aspects of Local Boiling Effects on Density and Pressure Drop..59—HT-18... By C. P. Costello, Assoc. Mem. ASME, University of Washington, Seattle, Wash. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

An accurate method of determining average density and static pressure drop due to liquid acceleration during boiling of subcooled liquids has been devised and employed in the tests reported in this paper.

The effects of system parameters and geometry on average density and acceleration pressure drop are discussed quantitatively.

A semianalytic method of predicting average density and acceleration pressure drop caused by vapor formation is proposed.

The method relies on photographic data and appears to be valid only to the point at which bubbles coalesce to form vapor clots.

It is also indicated that the most severe effects of vapor formations occur if vapor clotting takes place.

Steam Slip—Theoretical Prediction From Momentum Model..59—HT-15... By S. Levy, Assoc. Mem. ASME, General Electric Company, San Jose, Calif. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

Theoretical equations governing slip effects in forced circulation of boiling water are derived. The equations indicate that steam slip is dependent upon channel geometry, inlet water velocity, and rate of heat addition.

A simplified momentum model is postulated which leads to equal friction and head losses of two phases. The model gives good agreement with available experimental results in horizontal and vertical test sections with and without heat addition at pressures from 12 to 2000 psia.

Discussion of the model in terms of nonquasi-steady-state unbalances of friction and head losses of the two phases explains experimental deviations from the predictions and the previously noted effects of water inlet velocity. It also gives trends for the effects of channel geometry and rate of heat addition.

Application of the simplified model to calculating two-phase pressure drops is included.

Laminar Transfer From Isothermal Spanwise Strips on a Flat Plate..59—HT-1... By H. H. Sogin, Assoc. Mem. ASME, Brown University, Providence, R. I. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

The Rubesin-Klein-Tribus method is used to calculate rates of heat transfer by forced convection from two isothermal spanwise strips in tandem. The general results are applicable to either laminar or turbulent flow. Predictions of laminar transfer are based on Eckert's step function.

In experimentation, naphthalene cast in trays is used to simulate the isothermal strips while the inert material between them simulates the adiabatic wall. The velocities range from about 40 to 90 ft/sec, and the air temperature from 72 to 88 F. The boundary layer is shown to be laminar.

The theoretical and experimental results are found to be in good agreement, confirming the calculation method and Eckert's step function.

The experimentation is extended to an array of several equally spaced strips in tandem. Effects of roughness and spanwise diffusion are noted.

Pressure Drop and Heat Transfer in a Duct With Triangular Cross Section..59—HT-10... By E. R. G. Eckert, Mem. ASME, and T. F. Irvine, Jr., University of Minnesota, Minneapolis, Minn. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

Friction factors have been measured for a duct whose cross section has the shape of an isosceles triangle with a side ratio 5 to 1 in the fully developed flow region for laminar, transitional, and turbulent conditions. In addition, local and average heat-transfer coefficients and the temperature field in the duct wall have been determined for the condition of constant heat generation per unit volume of the duct walls.

Friction factors in laminar flow agreed well with analytical predictions. In the turbulent flow range they were by 20 per cent lower than values calculated from relations for a round tube with the use of the "hydraulic diameter." Heat-transfer coefficients averaged over the circumference of the duct were only half as large as values calculated from round tube relations in the Reynolds number range from 4300 to 24,000. The measurements also revealed that thermal starting lengths were in excess of 100 diameters. In round tubes a length of 10 to 20 diameters has been found sufficient to develop the temperature field.

Heat Transfer in Flow Through Rotating Ducts..59—HT-12... By C. Y. Kuo, Lehigh University, Bethlehem, Pa.; H. T. Iida, Assoc. Mem. ASME, Convair Astronautics Corporation, San Diego, Calif.; J. H. Taylor, Lehigh University, Bethlehem, Pa.; and F. Kreith, Assoc. Mem. ASME, University of Colorado, Boulder, Colo. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

Experimentally measured heat-transfer coefficients and visually observed flow phenomena for water flowing through an electrically heated rotating pipe with various inserts are reported.

Convection heat transfer in flow through a rotating pipe or a rotating annulus was found to be an exceedingly complex mechanism which cannot be treated adequately in terms of conventional parameters, but requires a detailed understanding of wave and vortex phenomena which were visually observed and photographed. Heat-transfer coefficients were measured in completely as well as partially filled flow channels. Three distinct flow regimes were observed in all cases; transition between regimes was found to depend on the rotational speed, but not on the axial-flow velocity. Stationary vortexes and a counterrotational fluid motion were observed.

Unsteady Turbulent Heat Transfer in Tubes..59—HT-16... By E. M. Sparrow, Assoc. Mem. ASME, and R. Siegel, Assoc. Mem. ASME, NASA, Lewis Research Center, Cleveland, Ohio. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

An analysis is made of the unsteady turbulent heat transfer in a circular tube whose wall temperature varies arbitrarily with time. The flow is steady and fully developed.

The formulation permits the heat-transfer coefficient to vary with time and position in accordance with the energy conservation principle. This is in contrast to previous transient analyses where it has been standard to use steady-state, fully developed coefficients.

The first step in the analysis yields the heat-transfer response to a step jump in wall temperature, and this is then generalized by a superposition technique to apply to arbitrary time variations.

Use of the generalized results is illustrated by application to the case where the wall temperature varies linearly with time.

Comparison is made between the unsteady heat-transfer results of the present theory and those computed using steady-state heat-transfer coefficients.

The Influence of Free-Stream Turbulence on the Local Heat Transfer From Cylinders..59—HT-3... By R. A. Seban, Mem. ASME, University of California, Berkeley, Calif. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

Local heat-transfer coefficients and recovery factors are presented for three different cylinders in a two-dimensional subsonic air flow, with emphasis on the effect of screen-produced turbulence on these quantities.

The increase in turbulent intensity so realized produced larger local heat-transfer coefficients, in a way dependent upon the location on the cylinders, through a direct increase in the heat transfer to the laminar boundary layer, through an earlier transition to turbulence, or through an alteration in the character of the separated flow.

Alternatively, recovery factors were affected less, being invariant with respect to the turbulent intensity for attached boundary-layer flow, but demonstrating large changes in those separated flow regions for which increased free-stream turbulence produced substantial changes in the nature of the separated flow.

Heat Transfer From Yawed Cylinders in Rarefied-Air Flows..59—HT-5... By L. V. Baldwin, V. A. Sandborn, and J. C. Laurence, National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

A Nusselt number correlation for yawed cylinders in subsonic slip and free molecule flow is presented which is a function of Reynolds number, Knudsen number N_{Kn} (or Mach number), and angle of yaw Φ^{21}. By using the velocity normal to the cylinder axis, $U_\infty \sin \Phi^{21}$, as the characteristic velocity, the yawed cylinder relation for all angles is identical with the Nusselt number correlation for a transverse cylinder in rarefied-air flows. That is, both Reynolds and Mach numbers must be based on $U_\infty \sin \Phi^{21}$ even for slow subsonic flows, so that the yawed wire results are correlated at constant Knudsen number.

Experimental data supply an empirical correlation for slip flow. Results of a free-molecule-flow analysis complete the heat-transfer correlation.

Conical Turbulent Boundary-Layer Experiments and a Correlation With Flat Plate Data..59—HT-6... By W. S. Bradfield, Convair, Scientific Research Laboratory, San Diego, Calif. 1959 ASME-AIChE Semi-Annual Meeting paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

Measurements in the turbulent boundary layer of unyawed cones for Mach numbers from 1 to 6 are presented. Specifically, the first measurements of total temperature profiles, directly determined skin friction, and local heat flux in the turbulent boundary layer of cone models are given.

In addition, these experimental data are shown to justify the calculation of turbulent friction and heat transfer on unyawed cones by means of an incompressible plate friction law and simple auxiliary relations.

Radiation Fin Efficiency for One-Dimensional Heat Flow in a Circular Fin..59—HT-8... By R. L. Chambers, Assoc. Mem. ASME, and E. V. Somers, Westinghouse Electric Corporation, Pittsburgh, Pa. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

It has long been known that the rate of heat transfer from a hot body to a cooler fluid may be increased by extending the body surface. Furthermore, the addition of fins extending into the fluid will cause an increased heat flow not directly proportional to the increase in body surface, since the temperature near the tip of the fin approaches the fluid temperature and causes a heat rate less than that which might be anticipated.

The one-dimensional steady-state solution for radiation from one side of an annular fin has been computed for values of the two design parameters $0 \leqslant \sqrt{\frac{\epsilon\sigma\theta_i^3}{K}}$ $(r_o - r_i) \leqslant 2.0$ and $1.001 \leqslant \rho = \frac{r_o}{r_i} \leqslant 15.0$. The solution supplies design information needed for satellite thermal-power dissipating surfaces.

Magnetohydrodynamic Effects Upon Heat Transfer for Laminar Flow Across a Flat Plate..59—HT-14... By R. D. Cess, Assoc. Mem. ASME, Westinghouse Electric Corporation, Pittsburgh, Pa. 1959 ASME-AIChE Heat Transfer Conference paper (in type; to be published in **Trans. ASME—J. Heat Transfer;** available to June 1, 1960).

Forced-convection heat transfer for laminar flow of electrically conducting fluids across a flat plate is considered for a magnetic field of constant inductance acting normal to the free-stream velocity and fixed relative to the plate.

The boundary condition on the surface of the plate is taken to be either a constant temperature or constant heat flux, and solutions are presented for the following cases: (*a*) Fluids having a Prandtl number of unity for which both Joule heating and frictional heating are accounted for; (*b*) fluids having moderate and large Prandtl numbers for negligible Joule and frictional heating; and (*c*) fluids having low Prandtl numbers for negligible frictional heating.

Experimental Determination of the Turbulent Heat-Transfer Rate Distribution Along a Slender Blunt-Nosed Body From Shock Tube Tests..59—HT-24... By E. Offenhartz and H. Weisblatt, AVCO Corporation, Wilmington, Mass. 1959 ASME-AIChE Heat Transfer Conference paper (multilithographed; available to June 1, 1960).

An experimental investigation has been undertaken using shock-tube techniques to determine the heat-transfer-rate distribution about a blunt-nosed cone-cylinder body at zero and nonzero angle-of-attack.

At zero degrees angle-of-attack it was

Applied Mechanics

Displacements and Stresses of a Laterally Loaded Semicircular Plate With Clamped Edges..59—APM-3... By W. H. Jurney, Colorado School of Mines, Golden, Colo. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A solution is obtained for the case of the clamped semicircular plate of constant thickness, subjected to a uniformly distributed normal load. The method employed is superposition of solutions for a circular plate with fixed edges.

The technique involved could be extended to study more general types of loading of the clamped semicircular plate.

Results are based on the assumption that the Kirchhoff, or small deflection, theory applies.

Extensional Vibrations of Elastic Plates..59—APM-4... By R. D. Mindlin, Mem. ASME, Columbia University, New York, N. Y., and M. A. Medick, Avco Manufacturing Company, Lawrence, Mass. 1959 ASME Summer Conference of the Applied Mechanics Division (in type to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A system of approximate, two-dimensional equations of extensional motion of isotropic, elastic plates is derived.

The equations take into account the coupling between extensional, symmetric thickness-stretch and symmetric thickness-shear modes and also include two face-shear modes.

The spectrum of frequencies for real,

found that the Van Driest and momentum turbulent-flow theories predict the trend of the experimental data for the entire body.

At angle-of-attack, the heat-transfer data were correlated in terms of the ratio of measured heat-transfer rates at angle-of-attack to zero values. A simple engineering approach permits the calculation of this ratio which closely predicts the trend of the experimental data.

Reactor Heat Transfer—A Preliminary Design Procedure..59—SA-16...By W. A. Sutherland, Assoc. Mem. ASME, Argonne National Laboratory, Lemont, Ill. 1959 ASME Semi-Annual Meeting paper (multilithographed; available to April 1, 1960).

Power reactors are primarily a heat source for the common Rankine or Brayton-cycle heat engines. As such, preliminary design studies of power-reactor cores should be investigated from a heat-transfer performance point of view.

This method, for nonboiling single-phase fluid systems, is used, together with a core effectiveness, to compare various fuel element geometries and primary coolants, as heat-transfer capability versus pumping power. It is thus possible to make rapid and accurate surveys of core designs.

A comprehensive comparison of reactor core design requires two things: (*a*) The various geometries must be described in an identical manner; and (*b*) the pumping power required must be compared for each geometry and coolant combination. Because the fraction of the core occupied by the coolant is of consequence to the reactor physicist, porosity is used as the design parameter, and comparisons are made between geometric configurations having the same porosity.

To describe thermal performance, a core effectiveness is defined on the basis of fluid and wall temperatures. The heat-transfer parameter, NTU, i.e., number of transfer units, is determined as a function of core effectiveness and power distribution.

imaginary, and complex wave numbers in an infinite plate is explored in detail and compared with the corresponding solution of the three-dimensional equations.

On Supersonic Wind Tunnels With Low Free-Stream Disturbances..59—APM-10...By M. V. Morkovin, Mem. ASME, The Johns Hopkins University, Baltimore, Md. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to April 1, 1960).

Measurements in supersonic wind tunnels have become almost routine in the last decade and yet little is known about the free-stream disturbances, which are present, and about the means of minimizing them. The present note outlines the problems of minimizing the mean as well as the unsteady variations of velocity and temperature and gives guidance where the trends are clear. It is found that in many wind tunnels the free-stream fluctuations are likely to be dominated by aerodynamic sound in the sense of Lighthill and by shivering Mach waves. Only conjectures can be offered on the means of minimizing the resulting sound intensity at the present time.

Triaxial Tension at the Head of a Rapidly Running Crack in a Plate..59—APM-11...By J. M. Frankland, National Bureau of Standards, Washington, D. C. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to April 1, 1960).

The conditions near a crack in a plate, whether stationary or growing, are usually considered to be a state of plane stress.

In this note, however, it is shown that appreciable normal stress through the thickness can occur when the crack is growing rapidly.

This gives rise to a state of triaxial tension in the core of the plate near the head of the crack and can thus contribute to the brittle behavior observed in such cases.

The amount of triaxiality is strongly dependent on the extent of the plastically deformed zone at the end of the crack.

This fact may be one reason for the greater brittleness shown by thick plates.

On Critical Speeds of a Shaft Supported by a Ball Bearing..59—APM-12...By Toshio Yamamoto, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Japan. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to April 1, 1960).

It is shown that two kinds of critical speeds induced by a slight difference in the diameter of balls in a ball bearing appear in a rotating shaft supported by ball bearings. These two critical speeds have peculiar modes of vibrations which are determined by dimensions of ball bearings; one of them is motion of forward precession, the other is backward precession.

The paper describes the cause of these critical speeds and the behavior of those vibrations.

Symmetric Vortex Separation on Circular Cylinders and Cones..59—APM-13...By A. E. Bryson, Harvard University, Cambridge, Mass. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to April 1, 1960).

The symmetric vortex separation that is observed on the leeward side of slender bodies of revolution at high angle of attack in the subsonic to moderately supersonic-velocity range is analyzed by means of the "lumped-vorticity" approximation suggested by Edwards and Hill.

The equivalent unsteady two-dimensional problem of indicial motion of a cylinder in an incompressible fluid with symmetric vortex wake is also considered.

Body vortex position and normal force per unit length are presented for a cylinder and a slender cone at high angle of attack and compared with available experimental information.

The Drag on Spheres and Cylinders in a Stream of Dust-Laden Air..59—APM-14...By Thomas Gillespie, The Dow Chemical Company, Midland, Mich., and A. W. Gunter, Defense Research Board, Suffield Experimental Station, Ralston, Alberta, Canada. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to April 1, 1960).

A system has been developed for measuring the drag on small spheres and cylinders in a stream of dust-laden air. The drag was found to be proportional to the kinetic energy of the air plus the kinetic energy of the dust, and to be independent of particle size for particles having diameters in the range of 50 to 400 μ.

The well-known drag-coefficient versus Reynolds-number plots are the same for dust-free and dust-laden air provided the drag coefficient is calculated using the density of the two-phase system and the Reynolds numbers are calculated using the density of air alone. This suggests that the dust has little effect on the flow pattern. The results indicate that an instrument utilizing the drag principle to measure dust concentration could be developed.

Incremental Stress-Strain Law Applied to Work-Hardening Plastic Materials..59—APM-15...By Chintsun Hwang, Mem. ASME, The National Cash Register Company, Hawthorne, Calif. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.**; available to April 1, 1960).

For problems involving work-hardening plastic materials, the incremental stress-strain law is considered to be a more rational approach than the conventional total stress-strain law. Up to

the present the incremental stress-strain law was not subject to widespread use because it is mathematically inconvenient to handle.

In this paper a method is developed in which the incremental law is applied to a work-hardening material in plane stress corresponding to the yield condition of von Mises.

The method is illustrated by an analysis of the plastic bending of a simply supported work-hardening circular plate under uniformly distributed transverse load.

The resulting difference-differential equations are solved by the NCR 304 digital computer.

Carrying Capacity of Elastic-Plastic Shells With Various End Conditions, Under Hydrostatic Compression..59—APM-16.. By Burton Paul, Assoc. Mem. ASME, Brown University, Providence, R. I. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

The influence of the beam-column effect on the carrying capacity of hydrostatically loaded elastic-plastic cylindrical shells is considered in this paper.

Specific problems considered include shells with clamped ends, simply supported ends, and a combination thereof.

It is shown that in all cases considered there exist two characteristic modes of failure corresponding, respectively, to long and short shells where the terms "long" and "short" are unambiguously defined. Detailed results are presented graphically along with general conclusions useful for design purposes.

The Stress Distribution in a Semi-Infinite Strip Subjected to a Concentrated Load.. 59—APM-17... By P. S. Theocaris, Mem. ASME, Brown University, Providence, R. I. 1959 ASME Summer Conference of the Applied Mechanics Division (in type, to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A solution is presented for the stress distribution in a semi-infinite strip subjected to an axial concentrated compressive load. The problem is solved by using the function $z = f(w)$ defining the Schwarz-Christoffel transformation.

All the boundary conditions are satisfied except along the two longitudinal edges of the strip. Normal stresses along these boundaries are present which are eliminated by applying the minimum-strain-energy principle at a part of the strip.

The stress components are calculated along all the boundaries and the axis of symmetry, as well as along three transverse sections in the neighborhood of the applied load.

The theoretical results are compared with experimental results obtained by using photoelasticity and the electrical analogy method for the tracing of isostatics.

Upper and Lower Bounds for Special Eigenvalues..59—APM-18... By F. C. Appl, Assoc. Mem. ASME, Jersey Production Research Company, Tulsa, Okla., and C. F. Zorowski, Assoc. Mem. ASME, Carnegie Institute of Technology, Pittsburgh, Pa. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A method for finding upper and lower bounds for the fundamental eigenvalue in special eigenvalue problems is presented.

The method is systematic and is shown to provide convergence from above and below to the exact eigenvalue under certain conditions.

The method is based on the relatively well-known enclosure or comparison theorem of Collatz, and makes use of a power series to approximate the eigenfunction. The method is applied to two examples concerning the critical-elastic buckling load of variable-section columns with pinned ends. Results for the first example compare well with the exact solution, which is known; the second example is presented as an addition to the literature.

Density Variation in Stepped-Thrust Bearing..59—APM-19... By C. F. Kettleborough, University of Auckland, N. Z. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

The problem of the stepped-thrust bearing is considered but, whereas normally volumetric continuity is assumed, the equations are solved assuming mass continuity; i.e., the variation of density is also considered as well as the effect of the stepped discontinuity on the load-carrying capacity and the coefficient of friction.

Computed theoretical curves illustrate the importance of the density on the operation of this bearing and, in part, explain results already published.

On Invariant Perforation in an Infinite Strip..59—APM-20... By Chih-Bing Ling, Tapei, Taiwan, China. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

The invariant perforation in an infinite strip can be classified into two groups. One is the finite group and the other is the infinite group. There are five cases in the finite group and nine cases in the infinite group. All the cases can be solved by the method of images.

This method has, in fact, been used by the author to solve the stresses in an infinite strip containing either an unsymmetrically located single hole or a series of uniformly distributed equal holes.

The solution is illustrated by working out in detail one of the cases in the infinite group, in which the strip contains two series of equal holes symmetrically staggered along the strip. The stress function is constructed by using a class of periodic harmonic functions derived from Weierstrass' sigma function.

Numerical examples also are given to show the effect of such a perforation on the stresses in the strip.

Piping Flexibility Analysis by Stiffness Matrix..59—APM-24... By L. H. Chen, Mem. ASME, General Dynamics Corporation, Groton, Conn. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A method of analysis is formalized for the solution of thermal-expansion stress problems in piping systems. The method is particularly suited for a complex system involving many anchors, closed loops within loops and/or interconnecting branch lines but without intermediate partial constraints.

A summary of formulas and procedures necessary for practical application is included in the Appendix. Emphasis has been placed on the simplicity of the procedures which are well suited for automatic computation in digital computers.

The Stress Function of a Radial Strain... 59—APM-25... By F. Goded, General Electrica Espanola, Madrid, Spain. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A stress function which permits the study of radial strain and, in particular, the manner of determining this stress function in a given cone, is derived in this paper.

Equations are developed using spherical co-ordinates.

The Determination of Safe Loads of Beams Subjected to Combined Twisting and Biaxial Bending Moments..59—APM-26... By P. G. Hodge, Jr., Mem. ASME, and R. Sankaranarayanan, Illinois Institute of Technology, Chicago, Ill. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

Using the lower-bound theorem of limit analysis, a yield criterion is obtained in terms of the stress resultants for a beam, subjected to combined twisting and biaxial bending moments. Based on a piecewise linear approximate

yield condition, the "collapse load" is determined for a right-angle bent, subjected to a load in an arbitrary direction applied to the mid-point of one leg. Such a collapse load, which is a "safe load" for the beam, is plotted as a function of a suitable parameter.

Note on a Thermoelastic Problem for a Transversely Isotropic Hollow Sphere Embedded in an Elastic Medium..59—APM-27...By J. Nowinski, University of Wisconsin, Madison, Wis. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

The problem of an isotropic thick-walled tube embedded in an elastic medium of the Winkler type, under internal pressure and a uniform temperature increase has been studied by B. G. Galerkin. In a recent paper, the Galerkin problem has been generalized to an orthotropic cylinder subjected to any axisymmetric temperature field. The present note is confined to a further generalization of the Galerkin problem, in connection with the anisotropic bodies, using the results of a previous paper by the author. In this paper a thermal steady-state polar symmetrical temperature field in a thick-walled transversely isotropic vessel has been studied. Thus the present paper deals with the Galerkin problem for such a two-layer anisotropic vessel. It seems that the problem considered may be of practical interest in some instances, such as that of a reinforced-concrete container, with a special inner coating, surrounded by a rocky ground and subjected to an internal pressure and a temperature field.

Viscous Flow Through Tubes of Multiply Connected Cross Sections..59—APM-28...By F. A. Gaydon and H. Nuttall, University of Bristol, Bristol, England. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

A new method is proposed for estimating the volume flow of a viscous incompressible fluid through a cylindrical tube of multiply connected cross section. The method brackets the magnitude of the volume flow between upper and lower bounds. The essential feature of the method is that the calculation of both upper and lower bounds is based upon the same approximating function for the velocity distribution, thus avoiding the usual approach to a lower bound via the Rayleigh-Ritz method.

For multiply connected cross sections of the form discussed, a Rayleigh-Ritz solution of sufficient accuracy becomes extremely laborious. Efforts to solve the problem by relaxation methods are also rendered difficult by the presence of high-velocity gradients in the vicinity of an internal boundary, particularly when this is a small circle. In contrast to these methods the one presented achieves the result with considerably less labor; moreover, the method is directly applicable to simply connected cross sections with many-sided boundaries.

On the Instability and Folding Deformation of a Layered Viscoelastic Medium in Compression..59—APM-21...By M. A. Biot, Mem. ASME, Shell Development Company, New York, N. Y. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

When a layer of material embedded in an infinite medium is subject to a compression parallel with the layer an instability tends to develop which manifests itself in the folding of the layer. This phenomenon is examined here for the general case where the layer and the surrounding medium are both viscoelastic. This problem which was examined in preliminary form in an earlier publication is treated here with particular attention to the effect of interfacial adherence of the layer and the medium, and to an evaluation of the amplitude of the folding.

In general, there is a lower and upper-critical value of the compressive load between which folding occurs with a finite rate of deformation. There appears also a dominant wave length, for which the rate of folding is maximum under a given load. The dominant wave length may or may not depend on the load. The effect of interfacial adherence while not negligible is not generally significant. The rate of folding increases very rapidly beyond a certain value of the viscosity ratio of the two media. A brief discussion is also included of the thermodynamic implications of incremental stress-strain relations in prestressed media.

Vibration of Beam-Mass Systems With Time-Dependent Boundary Conditions..59—APM-22...By T. C. Yen, Assoc. Mem. ASME, The Franklin Institute Laboratories for Research and Development, Philadelphia, Pa., and S. Kao, The M. W. Kellogg Company, New York, N. Y. 1959 ASME Summer Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to April 1, 1960).

The vibration problem of a beam with time-dependent boundary conditions can be solved by using Laplace transforms or by transforming the nonhomogeneous boundary conditions into homogeneous ones and thus solving a nonhomogeneous differential equation.

The fundamental frequency of a simply supported beam with a concentrated mass at mid-point and a cantilever with a concentrated mass at the free end can be obtained by classical methods. For a beam with an arbitrarily located concentrated mass, the natural frequencies have been obtained by making use of series expansion. By using Laplace transforms, employed for the solution of problems presented in this paper, closed-form frequency equations can be obtained readily for a beam with several concentrated masses.

The present analysis is related to numerous practical engineering problems. Typical among these are the vibration of piping systems carrying large valves, structures with heavy machinery subjected to earthquake or other excitation, and problems in a moving vehicle such as truck frames and airplane-wing assemblies.

Developments in the Application of the Grid Method to Dynamic Problems..59—APMW-1...By A. J. Durelli, J. W. Dally, Assoc. Mem. ASME, and W. F. Riley, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

The objective of the research reported in this paper was to develop the grid method further for use in dynamic-stress studies.

A rubber-thread grid network in a low-modulus model material (a urethane rubber known as Hysol 8705) was used in conjunction with a microflash light source to record grid distortions and photoelastic fringe patterns in a model subjected to dynamic-loading conditions. By considering a strut subjected to axial impact it was possible to establish that the static and dynamic values of Poisson's ratio were identical, and the strain-fringe value of the material varied with strain rate.

In addition, stresses in the axial and transverse directions were determined along the center line of the strut.

Finally, the methods established were applied to the problem of a circular disk subjected to diametrical impact and both principal stresses were determined along a vertical diameter at one instant during impact.

Axially Symmetric Waves in Elastic Rods..59—APMW-2...By R. D. Mindlin, Mem. ASME, Columbia University, New York, N. Y.; and H. D. McNiven, University of California, Berkeley, Calif. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

A system of approximate, one-dimensional equations is derived for axially

symmetric motions of an elastic rod of circular cross section.

The equations take into account the coupling between longitudinal, axial shear, and radial modes.

The spectrum of frequencies for real, imaginary, and complex wave numbers in an infinite rod is explored in detail and compared with the analogous solution of the three-dimensional equations.

Rupture Characteristics of Safety Diaphragms..59—APMW-3... By N. A. Weil, The M. W. Kellogg Company, New York, N. Y. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

Instability (maximum pressure) criteria for materials obeying a parabolic stress-strain law are investigated.

Two special solutions are formulated, accompanied by the instability condition obtained from the author's approximate theory.

Bursting pressure is most accurately predicted by the approximate theory. In turn, the polar deflection and strain at instability are more closely predicted by special solution II.

It is shown that neither the "pureness" nor the annealed condition of a metal gives adequate assurance of reliability in frangible disk service. The way to insure this requirement is to confirm experimentally that, in the uniaxial test, fracture will not occur before the logarithmic strain exceeds roughly (0.36 + 0.73 m), or that in a bulge test the applied hydrostatic pressure passes through a maximum prior to bursting.

Response of a Nonlinear String to Random Loading..59—APMW-4... By T. K. Caughey, California Institute of Technology, Pasadena, Calif. 1959 West Coast Conference of the Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

This paper considers the response of a nonlinear string to random excitation.

It is shown that, owing to the additional stress induced by the stretching of the string, the mean-squared deflection at every point is smaller than that for the equivalent linear string.

Response of Van Der Pol's Oscillator to Random Excitation..59—APMW-5... By T. K. Caughey, California Institute of Technology, Pasadena, Calif. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

This paper considers the response of Van der Pol's oscillator to random excitation.

It is shown that the output of the oscillator consists of a periodic term, plus a narrow band noise term centered at the natural frequency of the oscillator.

The root-mean-square amplitude of this noise term is shown to be proportional to the square root of the spectral density of the excitation, and inversely proportional to the amplitude of self-oscillation.

Slow Rotatory Motion of a Circular Disk About One of Its Diameters in a Viscous Fluid..59—APMW-6... By R. P. Kanwal, University of Wisconsin, Madison, Wis. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

Investigations regarding the motion set up in an infinite mass of viscous fluid when a circular disk is being translated edgewise as well as broadside-on have been made as a limiting case to the motion of an oblate spheroid. The case of a steady rotation about its normal axis has been studied by Jeffery as a limit to the case of an oblate spheroid rotating about its major axis. Jeffery, however, outlined an independent approach in terms of certain dual integral equations for this particular mode of motion of the disk but could not give a complete analysis. These integral equations are a special case of the integral equations which have been discussed subsequently by Titchmarsh and Busbridge. It is a matter of simple verification that all the afore-mentioned three modes of motion of the disk can be solved by the use of the dual integral equations as pointed out by Jeffery for the case of one of these modes of motion. In fact, Gupta has recently discussed the case of its broadside-on translation by this method.

There is a fourth mode of motion of the disk; namely, its steady rotation about a diameter in its plane. This case does not appear to have been discussed so far. The reason apparently is that it cannot be analyzed as a limiting process to the motion of an oblate spheroid. The purpose of this paper is to provide a solution for this case by the use of the integral equations mentioned previously. The accuracy of results has been checked by employing certain limit processes to the solution of the corresponding problem in elastostatics recently solved by Bycroft.

On the Effect of Shear on Plastic Deformation of Beams Under Transverse Impact Loading..59—APMW-7... By B. Karunes and E. T. Onat, Assoc. Mem. ASME, Brown University, Providence, R. I. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

The impact problem for a rigid-plastic beam is formulated by using an interaction curve relating shearing force and bending moment for fully plastic action and allowing for shear and rotary inertia effects. Using a simplified interaction diagram, the problem of point-impact loading is solved for a special case. The analysis shows that the shear effects are of considerable importance when the parameter $\mu_0 - 2Q_0l/M_0$ is less than 20 where Q_0 and M_0 are plastic-carrying capacities of cross section for pure shear and bending, respectively, and $2l$ is the length of the beam.

Viscous Damping in Flexural Vibrations of Bars..59—APMW-8... By M. K. Newman, Mem. ASME, University of Notre Dame, Notre Dame, Ind. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

Energy dissipation in flexural vibrations is considered by introducing into the Timoshenko beam equation viscous-damping terms proportional to the time rate of extensional strain.

Two modes of wave transmission arise from the roots of a quartic equation. On the lower mode, a solution is indicated in terms of characteristic functions which represent the damped natural vibrations.

For a specified range of values of damping, the amplitudes of natural vibrations are governed by characteristic damping factors which exhibit a maximum in the region of frequencies where wave velocities are dispersed.

There can be no frequency cut-offs.

In the higher mode of wave motion, the characteristic damping factors exhibit a monotone increase toward short wave-length limits analogous to those obtained in the Bernoulli-Euler-Sezawa equation.

Postbuckling Behavior of Rectangular Plates With Small Initial Curvature Loaded in Edge Compression..59—APMW-22... By Noboru Yamaki, Tohoku University, Sendai, Japan. 1959 West Coast Conference of the ASME Applied Mechanics Division paper (in type; to be published in **Trans. ASME—J. Appl. Mech.;** available to July 1, 1960).

In the previous paper (ASME paper No. 58—A-59, of which this is a continuation), the title problem is theoretically treated under eight different boundary conditions and numerical solutions are obtained for the deflection, edge shortening, and effective width of the square plate in edgewise compression.

As a continuation of this work, the stress state in the buckled plate is investigated and numerical results for the square plate are given graphically. Further, the formulas for the ultimate load of the square plate in each case are derived by using the maximum-shear theory for the beginning of yielding, and comparison is made with the previous results and experiments.

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Journal of APPLIED MECHANICS

Vol. 81 • Series E • No. 3

TECHNICAL PAPERS

319 On Supersonic Wind Tunnels With Low Free-Stream Disturbances, M. V. Morkovin. (59—APM-10)

325 Velocity and Temperature Fluctuation Measurements in a Turbulent Boundary Layer, D. S. Johnson. (58—A-81)

337 Density Variation Effects in Stepped-Thrust Bearings, C. F. Kettleborough. (59—APM-19)

341 Response of a Nonlinear String to Random Loading, T. K. Caughey. (59—APMW-4)

345 Response of Van Der Pol's Oscillator to Random Excitation, T. K. Caughey. (59—APMW-5)

349 A Perturbation Solution of the Equations of Motion of a Gyroscope, Robert Goodstein. (59—A-5)

353 Vibration of Beam-Mass Systems With Time-Dependent Boundary Conditions, T. C. Yen and S. Kao. (59—APM-22)

357 Dynamic Loading Tests of an Aircraft-Type Beam, E. A. Ripperger and W. R. Barton.

367 Viscous Damping in Flexural Vibrations of Bars, M. K. Newman. (59—APMW-8)

377 Natural Modes and Their Stability in Two-Degree-of-Freedom Systems, R. M. Rosenberg and C. P. Atkinson. (58—A-57)

386 On Finite Bending of Pressurized Tubes, Eric Reissner. (59—APM-5)

393 Instability and Folding Deformation of a Viscoelastic Medium in Compression, M. A. Biot. (59—APMW-21)

401 Stress Distribution in Semi-Infinite Strip Subjected to Concentrated Load, P. S. Theocaris. (59—APM-17)

407 Postbuckling Behavior of Rectangular Plates With Small Initial Curvature, Noboru Yamaki. (58—A-59)

415 New Theory of Elastic Sandwich Plates—One-Dimensional Case, Yi-Yuan Yu. (59—APM-23)

422 On Invariant Perforation in an Infinite Strip, Chih-Bing Ling. (59—APM-20)

432 Thermal Stresses in Moderately Thick Elastic Plates, B. E. Gatewood. (59—APM-7)

437 Analysis of Plane Stress in Polar Co-ordinates, H. D. Conway. (59—APM-1)

440 The Stress Function of a Radial Strain, F. Goded. (59—APM-25)

442 Determination of Safe Loads of Beams Subjected to Twisting and Bending Moments, P. G. Hodge, Jr., and R. Sankaranarayanan. (59—APM-26)

Journal of BASIC ENGINEERING

Vol. 81 • Series D • No. 3

275 Static and Dynamic Control Characteristics of Flapper-Nozzle Valves, by T.-Y. Feng. (58—A-160)

285 Some Measurements of Boundary-Layer Growth in a Two-Dimensional Diffusers, by J. F. Norbury. (58—A-196)

297 The Skewed Boundary Layer, by E. S. Taylor. (58—A-113)

305 On the Nature of Stall, by S. J. Kline. (58—A-170)

321 Optimum Design of Straight-Walled Diffusers, by S. J. Kline, D. E. Abbott, and R. W. Fox. (58—A-137)

332 Labyrinth-Seal Leakage Analysis, by W. Zabriskie and B. Sternlicht. (58—A-118)

341 Centrifugal Manometer, by J. F. Kemp. (58—A-111)

349 The Aerodynamic Design of Two-Dimensional Turbine Cascades for Incompressible Flow With a High-Speed Computer, by H. N. Cantrell and J. E. Fowler. (58—A-141)

362 An Analysis of Axial Compressor Cascade Aerodynamics, Part I, by G. L. Mellor. (58—A-83)

379 An Analysis of Axial Compressor Cascade Aerodynamics, Part II, by G. L. Mellor. (58—A-84)

387 Loss and Stall Analysis of Compressor Cascades, by Seymour Lieblein. (58—A-91)

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417 Modulation Phenomena in Stall Propagation, by J. A. Rockett. (58—A-152)

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59—Pet-29	59—HT-25	59—APMW-3
59—HT-1	59—HT-26	59—APMW-4
59—HT-2	59—HT-27	59—APMW-5
59—HT-3	59—HT-28	59—APMW-6
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COMMENTS ON PAPERS

Recruiting the Engineer

Comment by Paul L. De Bacco[1]

I AGREE with most of the author's remarks.[2] However, based upon my experience in recruiting engineers and other scientific people, I have concluded that they have four basic wants or drives that must be satisfied in order for them to be both productive and happy in their job. These are: (1) Desire for recognition, (2) need for security, (3) the feeling of belonging, and (4) new experiences.

1 Desire for Recognition. The engineer and scientist, like other people, wants to be recognized. He likes to be told occasionally that he is doing a good job and that he is contributing something to the betterment of the organization.

2 Need for Security. Security means reasonable freedom from worry, fear, and anxiety. It appears to me that the engineer and scientist are much more interested in security than the average individual. In interviewing experienced engineers and scientists I have often come across individuals who had with them a little notebook containing questions about fringe benefits that they wanted to be sure they had answers to. They always appeared to be quite concerned about pension plans, hospitalization benefits, stability of the organization, and so on. In a few cases, and by few I mean 20 to 25 per cent of the time, I was asked about the promotional opportunities within the organization. Whether this is a common thing or something I, alone, have experienced I don't know.

3 The Feeling of Belonging. In talking to engineers and scientists I often ask what they want from a job. Invariably they all say that they want to work for a company in which they can feel that they are "part of a team and are in on things." Quite often an engineer or scientist is hired and placed in an office and pretty much forgotten, and little effort is made to keep him informed of things that are taking place within the organization. Organizations can win an emotional attachment for the company if they will find the means of telling employees about the company, its history, its policies, and aims. Being told what is happening and why goes a long way toward satisfying this need.

4 New Experiences. The engineer and scientist, like all of us, are looking for work that is challenging, interesting, and stimulating. If a good engineer is placed in a routine job that presents no challenges to him, he will leave the company. It is management's job to give the engineer and scientist assignments that will satisfy this need for new experiences.

While these four basic drives are associated with the engineer and the scientist, they also apply to other individuals. The degree to which they exist, however, will vary.

[1] Regional personnel manager, Celanese Corp. of America, New York, N. Y.

[2] R. G. Alleman, "Recruiting the Engineer," MECHANICAL ENGINEERING, vol. 81, April, 1959, pp. 65–66.

Comment by Arthur M. Krill[3]

This paper[2] is a most comprehensive and interesting presentation of the method of engineering recruitment being conducted by one of our large industrial firms. The author's remarks point up the need for a dynamic approach to the problem of maintaining a steady flow of technically trained manpower into the bloodstream of any progressive company.

An operating investment per employee of some $27,000 to $28,000 is indicative of the value of the individual employee to management and the stockholders. Properly placed and well-adjusted workers are a necessary ingredient for an efficient operation in this competitive era. It seems desirable, then, that recruiting technical men be a career occupation of a selected group of interested technical men for some protracted period. I heartily endorse the use of scientifically trained men to recruit for the technical areas, and I also believe that they must have at least moderate training in personnel work and possess a suitable personality to be effective contact men in such assignments.

The author has emphasized the advantages to employee and company which accrue from a summer-employment technical program. Although I believe that such a program is no substitute for true co-operative education, it does give prospective employee and employer at least one opportunity to examine one another at firsthand. The nearly double acceptance rate of summer employees over other college-recruited technical candidates who received offers, and the demonstrated lower turnover among workers possessing five years' experience with the company, indicate the influence of the work-experience system on recruiting efficiency.

The Co-operative Plan of Engineering Education offers the ultimate in providing an interesting and efficient transition between classroom and industrial assignment. Under this system the young engineer-in-training has several times the opportunity to observe and learn on the job as he has in the relatively successful summer-employment program de-

[3] Head, Mechanics Division, Denver Research Institute, University of Denver, Denver, Colo. Mem. ASME.

scribed by the author. The alternate periods of academic training and industrial experience not only bridge the gap between the somewhat different environments, but also permit technical facts to be brought into focus and anchored more firmly in the student's mind.

The responsibility of the recruiter under a co-operative arrangement is not reduced to zero, but first placements can be made at the undergraduate level, and errors are more easily corrected. For this reason I believe that participation in the Co-operative Plan is an important consideration for companies and engineering students alike in connection with the ultimate desire of both to form happy, lasting, and beneficial associations.

Comment by J. P. Rockfellow[4]

The importance of the same recruiter or representative interviewing at a given school over a period of years should be emphasized. In this way he builds contacts which are of inestimable value.

In addition to getting well acquainted with the placement people, he has an opportunity to develop faculty contacts. Through these contacts a mutually valuable exchange develops. This may include referrals to likely candidates working on special graduate problems, former students, and those in the military. The faculty also give invaluable assistance in appraising students. Further, the liaison built up enables the faculty to receive valuable reports on how former students are progressing in their chosen fields. This can only work to the mutual benefit of the employer and the school.

An interesting note is that du Pont normally schedules 20-minute interviews. Because a large percentage of those considered are invited to visit du Pont facilities, the initial interview is augmented by this second meeting. Many companies, however, rely to a greater extent on the evaluation made from the initial interview, and only in particular cases is the applicant invited to visit company facilities prior to receiving an employment offer. Union Oil Company normally asks for 30 minutes. In this way we can not only make a fuller evaluation of the likely applicant, but also can assist others by counseling and avoiding the processing of numerous applications.

There are differences of opinion among recruiters as to whether or not notes should be taken during an interview. It is our belief that limited notes should be taken during the interview period or some pertinent information and impressions may be lost. After the applicant has left the room, final notations and a summary may properly be written. This procedure at least minimizes note-taking.

As mentioned by the author, we feel it is essential that candidates be given a true picture of the company. Also, to avoid an inflated conception by the engineer of his own values, it is necessary to maintain a competitive salary schedule—don't extend an offer for too high a starting salary "just to get the man."

The summer-employment program certainly is a most valuable method of building toward a mutually agreeable selection. It is important, however, to avoid re-employing a student on successive summers unless it is likely the company would want to offer him permanent employment upon graduation. Otherwise, both student and the company are placed in an awkward position.

[4] Manager of Employment, Union Oil Company of California, Union Oil Center, Los Angeles 17, Calif.

Thermal Performance of the Philo Supercritical Unit

Comment by J. D. Andrew, Jr.[5]

The operating results for the first year at Philo, as described in this paper,[6] are something for engineers in this country to be proud of. Better yet, it shows the way toward reduced kw costs, not only by more efficient heat cycles but by a simplified boiler design at less capital investment. The authors and the company they represent are to be commended in this pioneering success.

This report in simple form analyzes the operating efficiency test results. The over-all performance of the prime movers is better than predicted. It is the auxiliary losses that add up to more than "the expected." This important fact quite naturally leads us, as manufacturer of the boiler, to analyze our part in this deficiency.

1 Boiler Feed Pump. The water flow through the boiler is directly related to gross output, but the flow resistance of the once-through circuitry, which dictates the pump pressure, measured 13 per cent less than predicted at full load.

2 Forced and Induced Draft Fans. The gas weight was some 4 per cent less than that predicted, while the flow resistance was 14 per cent less.

3 Recirculating Gas Fan. The basic design called for 75 per cent gas recirculation as furnace tempering, made necessary by the furnace size being small due to building limitations. Gas temperature has been held down successfully to about 1930 F entering the superheater tubes, as originally calculated. The draft differential across this system is some 43 per cent less than predicted under clean furnace conditions. The fan is constant speed, requiring damper control, however. As reported, there is good reason to believe that the alternate windings of the motors for 80 per cent speed will be satisfactory.

4 Feedwater Clean-Up Cycle Pumps. Boiler-water quality control has met most satisfactorily the desired specifications. The tests reported upon were only about four months after initial start-up operation when silica contamination was undoubtedly more prevalent than today. This is a small item in today's normal operation.

In conclusion, 8886 Btu per net kwhr is a fine record over a seven-month operating period. The report one year from now should be substantially better.

[5] Executive Engineer, The Babcock & Wilcox Company, Barberton, Ohio.

[6] A. S. Grimes and J. A. Tillinghast, "Thermal Performance of the Philo Supercritical Unit," Mechanical Engineering, April, 1959, vol. 81, pp. 81–84, condensed from Paper No. 58—A-297.

Authors' Closure

Mr. Andrew's comment is an important addition to the paper and indicates the high degree of success which was achieved in the design of this first supercritical pressure boiler. Since the time of presentation of this paper, the tests and necessary evaluations have been carried out which have led to the decision to reduce operating speed of the recirculating gas fans to 80 per cent of their original speed. This modification has been in successful operation for several months.

The test program on the boiler feed-pump seals was completed and a new seal design has been successfully developed.

At the first convenient outage, this new seal will be installed. It is anticipated that this new seal will not only have high availability but will also reduce leakage losses to reasonable levels.

A. S. Grimes.[7]

J. A. Tillinghast.[8]

[7] Head, Results Section, American Electric Power Service Corporation, New York, N. Y. Mem. ASME.

[8] Staff Engineer, American Electric Power Service Corporation, New York, N. Y. Mem. ASME.

Notes on Books Received in Engineering Societies Library

REVIEWS OF BOOKS

Nuclear Rocket Propulsion

Nuclear Rocket Propulsion

By R. W. Bussard and R. D. DeLauer. McGraw-Hill Book Company, Inc., New York, N. Y., 1958. Cloth $5^1/_2 \times 9$ in., figs, references, tables, appendix, index, xiii and 370 pp., $10.

Reviewed by Wallace A. Moser[1]

NUCLEAR rocket technology, particularly with the inclusion of nuclear-electric propulsion, covers every phase of modern space-age engineering. The authors have succeeded in producing a clear-cut and comprehensive view of nuclear propulsion problems and design philosophy which will be instructive to every engineer working in even remotely related fields. The presentation of the material is in a descriptive manner, although the book has the format of a textbook. Pertinent equations are given without derivation, and few instructive examples are worked out, so that the continuity is good. The properties of the equations are not neglected, however. Many graphs of the behavior of the formula variables are included, so that the reader can gain insight into the relationship between different parameters at a glance. In some instances the notation may cause some difficulty, but this is more the fault of the tremendous scope of the book than any caprice of the authors. They point out that they have tried to adhere to the symbology used in each field, and have even allowed some duplication between sections where it is not confusing.

The organization of the book follows roughly the design procedure for a nuclear missile. The first section deals with general rocket performance; the thermochemistry of propellants, nozzle processes, and ballistic missile trajectories. The problems of satellite boost and space trajectories with nuclear rockets are not included; furthermore, at a later point mention is made of the nonreusable character of rocket reactors. Evidently the authors have decided to stick with the ballistic missile concept, rather than the satellite or space missile, for this edition. This is the only instance of progress in the field outdating the text which is evident, and this is certainly minor. The material presented by the authors will remain applicable even though rocket concepts may change.

The section on missile-system analysis is the first time this subject has been dealt with in a text. It is difficult to gain an understanding of the complex interdependence of missile component weight relations actually setting up a hypothetical rocket and attempting to balance conflicting factors, but sufficient examples and parametric weight representations are given so that a reader can follow through a first-order system analysis on his own.

In the sections on heat transfer and materials, particular emphasis is placed on the problems of thermal stability conditions and thermal stresses peculiar to a rocket reactor core during start-up and steady-state operation. The sections on nucleonics and system control are largely descriptive because only machine computation is realistic for obtaining any information other than gross estimates. A rocket reactor must undergo an extremely quick build-up to full power to avoid wasting propellant, and its dynamic and transient characteristics must be accurately determined. The book concludes with a review of possible rocket-testing procedures and some brief sketches of advanced methods of nuclear and nuclear-electric propulsion.

In addition to the graphs depicting the behavior of some of the equations, there is also included a large number of tables of useful formulas and tables of properties of materials (including a surprising 23 pages devoted to a nuclide chart). This reference information is helpful to a reader who wishes to make rough design calculations, as well as to a student who desires to acquire a working knowledge of the subject without having to consult the extensive bibliography. However, the book was not intended to be a handbook, and can easily be absorbed by the engineer wanting only to become acquainted with nuclear rockets. An excellent feature of the book in this respect is the unusually lucid explanations of the usefulness of mathematical techniques used in nuclear rocket design work, such as relaxation solutions, the Laplace transform, analog-computer simulation, control stability criteria, two-group neutron diffusion, and multigroup time-dependent machine calculations. The recent Kiwi reactor test pinpoints the timeliness of this book and its importance to the space-age engineer.

[1] Research engineer, Rocketdyne, Canoga Park, Calif.

Mechanics of Fluids

Advanced Mechanics of Fluids

Edited by Hunter Rouse. John Wiley & Sons, Inc., New York, N. Y., 1959. Cloth, $6 \times 9^1/_4$ in., figs, tables, problems, references, appendix, index, xiv and 444 pp., $9.75.

Reviewed by J. P. Johnston[2]

AS STATED in the preface to the book, it is intended to be used primarily as a text for a graduate fluid-mechanics course. There is little doubt in the reviewer's mind that it suits this purpose admirably. However, of what value is the book to an engineer working in industry on advanced fluid-dynamics problems?

The subject matter is almost completely devoted to the discussion of the mechanics of incompressible fluids. None of the subjects of great current interest such as magnetohydrodynamics, flow of reacting fluids (combustion), or flow of rarefied gases are discussed. Nevertheless, most qualified workers concerned with any of the above interests recognize the value of a solid background in incompressible-flow theory. The modern theories on these subjects have many direct and indirect roots in the mathematical techniques and physical concepts developed by the hydrodynamicist.

[2] Research engineer, advanced engineering department, Ingersoll-Rand Company, Phillipsburg, N. J.

The scope of material covered in the book may be judged by analysis of its contents. The introduction, chapter 1 (28 pages), includes an excellent discussion of the limitations of either mathematical analysis or experimentation when one approach is not guided and tempered by the other. It also contains some material on methods of dimensional analysis using the π theorm. Chapter 2 (39 pages) presents the physical concepts and equations that form the basis of the mathematical theories to follow. The foundations of potential flow theory are expounded in chapter 3 (75 pages) and various mathematical techniques (separation of variables, method of images, and method of integral equations) as well as approximate techniques for solving potential flow problems are discussed.

Methods of solving two-dimensional potential flow problems by conformal mapping are thoroughly covered in chapter 4 (57 pages). In chapter 5 (61 pages) the Navier-Stokes equations are developed and some of the exact and approximate solutions of these equations are presented. In addition, this chapter includes a 20-page section on the theory of stability of laminar flow. The fundamental concepts and equations of turbulent flow are presented in chapter 6 (45 pages) along with brief discussions of the theories of isotropic turbulence, turbulent diffusion, and turbulent shear flow.

Chapter 7 (53 pages) clearly sets out the approximations and equations of boundary-layer theory and presents the methods of exact solution of the two-dimensional (Falkner and Skan) and axisymmetric laminar boundary-layer flows. The inner and outer laws of turbulent velocity profiles, unsteady boundary layers, and some of the approximate methods of solving laminar and turbulent boundary-layer problems are discussed briefly. The last chapter (46 pages) presents the theoretical methods of free-turbulence shear flow as applied to jet mixing and wake-spreading problems. The book includes numerous problems, an excellent appendix on equations in curvilinear, orthogonal co-ordinates, but only a cursory subject index.

A worker with specialized interests would probably feel that coverage of material relative to his specialty was rather brief. However, he could not help but consider that the presentation of the material given is of high quality both from the point of view of mathematical depth and precision and clarity of exposition.

Major emphasis is placed on development of the mathematical methods which bear on the subject matter presented. However, the limitations, imposed by experience, on the various theoretical techniques are well presented throughout the book. The level of the writing is such that a reader without a firm background in advanced calculus will find the book of little value.

Without doubt, teachers of advanced courses in the mechanics of incompressible flow will welcome this book with enthusiasm, and research workers in the fluid-dynamics field should find it a useful addition to their reference libraries.

BOOKS RECEIVED IN LIBRARY

Radiation Hazards and Protection

By D. E. Barnes and Denis Taylor. 1959, Pitman Publishing Corporation, New York, N. Y. 178 p., $5^{3}/_{4} \times 8^{3}/_{4}$ in., bound. \$6.75. The nature of the radiation hazard is explained and the levels of radiation which are accepted as safe are presented. The authors then discuss the protective methods by which these safe levels can be attained, and the measurements that will show whether satisfactory conditions have been achieved. In a concluding section the radiological hazards arising from atomic warfare are examined, together with the protective measures possible. A considerable portion of the book is devoted to various types of instrumentation.

Radioisotopes in Scientific Research
Vol. I: Research With Radioisotopes in Physics and Industry.
Vol. II: Research With Radioisotopes in Chemistry and Geology.

Proceedings of the First (UNESCO) International Conference. 1958, Pergamon Press, Inc., New York, N. Y. $6^{1}/_{2} \times 10^{1}/_{4}$ in., bound. \$22.50 each. Volume one considers research with radioisotopes in physics and industry and contains papers discussing production of radioisotopes, dosimetry, design and use of strong sources, metallurgy, industrial applications, solid-state physics, and methods and techniques. Volume two considers research with radioisotopes in chemistry and geology and contains papers dealing with organic chemistry, recoil chemistry, analytical chemistry, physical chemistry, geophysics, and production of radioisotopes.

Reflex Klystrons

By J. J. Hamilton. 1959, The Macmillan Company, New York 11, N. Y. 260 p., $5^{3}/_{4} \times 9$ in., bound. \$9. An introductory survey of reflex klystrons. The author discusses cavity resonators and output systems, electron dynamics of the reflex klystron oscillator, load effects, engineering aspects, representative and unconventional reflex klystrons, and future trends. The practical aspects of reflex klystron manufacture are emphasized throughout, and descriptions of the physical processes occurring in actual tubes are given.

Refractories Bibliography 1947–1956

Compiled by The Joint Refractory Committee of the American Iron and Steel Institute and The Refractories Institute. 1959, University of Oklahoma Press, Norman, Okla. 1822 p., $8 \times 10^{3}/_{4}$ in., bound. \$7.50. This volume continues the previous compilation which covered the period 1928–1947. Over 9500 abstracts from the periodical literature and patents are included, and relate to the raw materials, manufacture, properties, and uses of refractories. Refractories in all phases of industrial use are covered, including glass industry, petroleum industry, and foundry refractories, as well as refractories for the iron and steel industry. Developments in high-temperature materials are given particular emphasis.

Solid State Physics: Advances in Research and Applications. Vol. 7.

Edited by Frederick Seitz and David Turnbull. 1958, Academic Press, Inc., New York, N. Y. 525 p., $6 \times 9^{1}/_{4}$ in., bound. \$12. Among those aspects of solid-state physics reviewed in the present volume are thermal conductivity and lattice vibrational modes, electron energy bands in solids, the elastic constants of crystals, wave packets and transport of electron in metals, study of surfaces by using new tools and the structure of crystals.

Statistical Quality Control

By Douglas H. W. Allan. 1959, Reinhold Publishing Corporation, New York, N. Y. 129 p., $5^{1}/_{4} \times 7^{1}/_{2}$ in., bound. \$3.50. Written for management personnel who wish to familiarize themselves with statistical quality control without the necessity of mastering the mathematical details of the technique. Following an introduction to the concepts involved and their place in management, the basic tools are then described including statistical concepts, process capabilities, statistical control charts, and statistical acceptance sampling. The book concludes with the methods used for investigations and their field of application and limitations.

Technische Laufwerke Einschliesslich Uhren

By Friedrich Assmus. 1958, Springer-Verlag, Berlin, Germany. 279 p., $6^{1}/_{2} \times 9^{1}/_{2}$ in., bound. 36 DM. A detailed treatment of driving and actuating mechanisms for precision devices. The first third of the book is devoted to the design of small spur and bevel gears. The remainder deals with spring drives, indicating mechanisms, gear trains, escapements, and alarm mechanisms as used in clocks, meters, and various recording devices.

Theory of Relativity

By W. Pauli. 1959, Pergamon Press, Inc., New York, N. Y. 241 p., $6^{1}/_{4} \times 10$ in., bound. \$6. The present volume is a reprint of an earlier edition, and in addition contains a series of supplementary notes which provide selected information about later developments as well as the author's personal views upon certain controversial questions. The five sections contained in the book deal with the founda-

tions of the special theory of relativity, mathematical tools, detailed aspects of the special theory of relativity, the general theory of relativity, and theories on the nature of charged elementary particles.

Thermodynamic and Transport Properties of Gases, Liquids, and Solids
Published 1959 by The American Society of Mechanical Engineers and the McGraw-Hill Book Company, Inc., New York, N. Y. 472 p., $8^1/_4 \times 11$ in., bound. $12.50. (Members of ASME, $10.) In addition to reviewing and evaluating the subject as a whole, the 42 papers included report a large amount of new data as well as recent techniques. The papers discuss transport properties from the standpoint of theory and experiment, and thermodynamic properties of liquids and gases, PVT data and equation of state, thermodynamic properties of boron compounds, high-temperature transport properties of metals and ceramics, and high-temperature thermodynamic properties of gases. These papers were presented at the Symposium on Thermal Properties held in February, 1959.

Tignes
Published 1958 by La Houille Blanche. Distributed by Editions Eyrolles, Paris, France. 440 p., 9×12 in., bound. 8000 fr. This group of papers by engineers connected with the work covers fully the hydraulic installations of Tignes in the French Alps. The Tignes Dam, one of the highest in the world, is described in detail, as are the problems encountered in its construction. The power plants at Brévière, Le Chevril and Ponturin, and the central plant at Malgovert are similarly treated. The book is profusely illustrated with photographs and diagrams.

Work Measurement
By V. H. Rotroff. 1959, Reinhold Publishing Corporation, New York, N. Y. 203 p., $5 \times 7^1/_2$ in., bound. $4.85. The need for better planning is stressed in this volume which discusses the setting of work standards and how to use and maintain them. All phases of the work measurement program are presented: Why work is measured and what it means to company personnel; the standard data approach; the economics of work measurement; the consultant's role; labor relations and work measurement. The methods and procedures described were developed from the first-hand experience of management consultants and industrial engineers actively engaged in the field of work measurement.

Die Zahnformen der Zahnräder
By Hermann Trier. Fifth Edition. 1958, Springer-Verlag, Berlin, Germany. 76 p., $6^1/_4 \times 9$ in., paper. 2.70 DM. A thorough mathematical analysis of the design of gear-tooth forms and systems. Beginning with a section on fundamentals, the book deals successively with straight-toothed spur gears, helical spur gears, bevel gears, and worm gears. The final section provides a group of numerical examples.

Adhesive Bonding of Reinforced Plastics
By H. A. Perry. 1959, McGraw-Hill Book Company, Inc., New York, N. Y. 275 p., $6 \times 9^1/_4$ in., bound. $8.75. This volume is intended to fill the gap which exists between the technology of adhesive bonding and the art of glass-fiber-reinforced plastic molding. It discusses the theory, equipment, design, production, and testing of adhesive bonded assemblies containing parts reinforced with glass fibers or similar fibrous materials. Specific topics included deal with the theory of the mechanics of adhesive joints, laminating resins and adhesives, rheology and general properties of adhesives, recent testing techniques, and quality control. Useful tables and a glossary are included.

Applied Mathematics for Engineers and Scientists
By C. G. Lambe. 1958, The Macmillan Company, New York, N. Y. 518 p., $6 \times 8^3/_4$ in., bound. $8.50. Three broad aspects are encompassed in this volume, beginning with dynamics which encompasses the motion of a particle, the plane motion of a rigid body, vector analysis, and Lagrange's equations. In addition there is an account of Fourier series, harmonic analysis, and small oscillations. This is followed by a discussion of statics, specifically statics of a rigid body, statics of strings and chains, and structural statics. The concluding chapters dealing with hydrodynamics treat the stability of floating bodies, Bernoulli's equation for liquids and gases, stream functions, and the standard atmosphere. A practical approach is maintained throughout, and numerous examples and exercises illustrate the solution of physical and engineering problems.

Bibliography on Industrial Radiology, 1956–1958
By H. R. Isenburger. 1959, St. John X-Ray Laboratory, Califon, N.J. 27 p., $8^3/_4 \times 11^1/_2$ in., paper. $4. The present volume is the seventh part of a continuing bibliographical supplement to "Industrial Radiology" (1943), by Ancel St. John and Herbert R. Isenburger, and is intended to provide access to later developments in this field. The continuing growth of this subject is reflected in the increased number of citations given for each year. With the advent of radioisotopes particular attention has been paid to safety precautions, as is indicated by the numerous references to this aspect.

Budgeting: Principles and Practice
By H. C. Heiser. 1959, The Ronald Press Company, New York, N. Y. 415 p., $6 \times 9^1/_4$ in., bound. $10. Emphasizes budgeting as a prime management tool for continuous profit planning and control. An introductory section provides an over-all review of budgeting for the purposes of planning and co-ordination. This is followed by a discussion of budgeting for control, including the measurement of deviations from expected performance standards established both for planned and actual operations. The concluding section studies in detail the actual techniques of budgeting and controlling each of ten major categories of income and expenditure, as well as budget revisions and alternative budgeting practices.

Constitutional Diagrams of Uranium and Thorium Alloys
By F. A. Rough and A. A. Bauer. 1959, Addison-Wesley Publishing Company, Inc., Reading, Mass. 153 p., $6^1/_4 \times 9^1/_2$ in., bound. $5. A compilation of uranium and thorium constitutional diagrams from United States and United Kingdom sources presented in compact reference form. It is divided into two major sections, uranium and thorium alloys, each preceded by a discussion of the transformation and melting temperatures of the base metal. The various systems are then listed in alphabetical order, including both binary and ternary systems. A modified "Metals Handbook" system of notation is employed in the preparation of the constitutional diagrams. While unclassified references are generally given, a few classified references are indicated where some systems are incomplete.

Creep of Engineering Materials
By Iain Finnie and William R. Heller. 1959, McGraw-Hill Book Company, Inc., New York N. Y. 341 p., $6 \times 9^1/_4$ in., bound. $11.50. The creep of materials is covered from the standpoint of design for creep conditions with sufficient detail provided to formulate and solve engineering problems. Illustrated treatment is given for such topics as measurement of creep variables, including temperature, strain, and load; mechanisms involved in the creep of metals and nonmetals; stress analysis under creep conditions; sources of creep data; factors in choosing a design stress; and creep problems occurring in specific applications. Typical creep curves and examples of engineering calculations are included.

Cryogenic Engineering
By Russell B. Scott. 1959, D. Van Nostrand Company, Inc., Princeton, N. J. 368 p., $6 \times 9^1/_4$ in., bound. $5.60. Although the practical aspects of cryogenic processes and equipment are emphasized, an effort is made to include the theoretical fundamentals required for understanding the subject. The major problems encountered in the development and application of low-temperature techniques are described, including the liquefaction and separation of gases, cooling by adiabatic demagnetization, measuring low temperatures, low-temperature insulation, and the storage and transfer of liquefied gases. Two concluding chapters provide handbook-type information on the properties of very cold fluids and solids. The material given treats of the most recent developments and is organized with a view to indicating the feasibility of any new project, as well as the difficulties which may be encountered.

Fluid Meters, Their Theory and Application
Fifth Edition. Published 1959 by The American Society of Mechanical Engineers, New York, N. Y. 203 p., $8^1/_2 \times 11^1/_4$ in., bound. $8. A revision of a standard work that encompasses classification and nomenclature, theory and fundamentals of fluid meters, and constants and factors useful in fluid metering. In addition to the expansion and revision of the text two changes have been made in the presentation of the subject. The gravitational system of units has been used in the development of equations and the presentation of physical data, and the coefficients of differential head meters are given on the basis of the pipe Reynolds number.

Forest Machinery
By E. R. Huggard and T. H. Owen. 1959, Adam and Charles Black, Ltd., London, England. 192 p., $5^3/_4 \times 8^3/_4$ in., bound. 24s. A general description of the varied machinery and equipment used in forestry and the maintenance of woodlands. Introductory chapters deal with mechanization in the forest, economic considerations, and the principles of the application and operation of machinery. These are followed by practical information on nursery equipment, machinery for land preparation and forest establishment, road construction plant, felling and rough conversion, extraction of timber from the point of felling, forest protection, and general machinery associated with these activities. Numerous illustrations accompany the text.

Fundamental Aspects of Reactor Shielding
By Herbert Goldstein. 1959, Addison-Wesley Publishing Company, Inc., Reading, Mass. 416 p., $6^1/_4 \times 9^1/_4$ in., bound. $9.50. Stress is laid on the fundamentals of the subject, specifically the factors affecting the permissible radiation levels, the sources and characteristics of the radiation to be shielded against, and how bulk shielding measurements are made. The book concludes with a detailed analysis of the calculations necessary to determine, theoretically or empirically, the attenuation of neutron

and gamma rays in shield materials. Although certain related fields such as radiation biology and nuclear physics are considered, a background knowledge on the part of the reader is assumed.

Fundamentals of Engineering Drawing
By W. J. Luzadder. Fourth Edition. 1959, Prentice-Hall, Inc., Englewood Cliffs, N. J. 720 p., $6^1/_4 \times 9^1/_4$ in., bound. $10. The basic aspects of the subject involving the use of instruments, lettering, engineering geometry, and multiview drawing are given at the outset in a revised presentation. In addition, the chapter on dimensional practices and on welding drawing are completely revised and a new chapter added on practical sketching. New problems are included as are 400 new illustrations. Surface shading is now used to permit rapid visualization of three-dimensional views. The latest ASA and SAE standards are used throughout.

Handbook of Architectural Practice
Eighth Edition. Published 1959 by The American Institute of Architects, Washington, D. C. Various pagings, $8^1/_2 \times 11^1/_4$ in., bound. $8. This handbook is intended to be useful to both the architect and his client. The first part deals with the building field and architectural practice in general as well as related legal aspects. Succeeding sections cover the organization and office procedures of architectural firms, and examine in detail the usual procedures of an architect in relation to a building project. An appendix gives a wide variety of sample forms and contracts. Although it is primarily written for small and medium-sized offices, larger offices will find it useful as will architectural students.

Handbook of Natural Gas Engineering
By D. L. Katz and others. 1959, McGraw-Hill Book Company, New York, N. Y. 802 p., $8^3/_4 \times 11^1/_4$ in., bound. $37.50. An extensive treatment of natural gas, beginning with its occurrence in the reservoir through its production, processing, and transportation to the ultimate consumer. Primary consideration is given to the properties of hydrocarbons and the application of these properties in flow and processing operations. Among the recent advances covered are turbulence factors for high velocity of flow through porous media, design methods for wells behaving in an unsteady manner, and flow calculations involving integrated functions of the compressibility factor and pressure. A special chart, based on core data for predicting the flow of natural gas from a well is included.

Heating, Ventilating, and Air-Conditioning Guide, 1959
Published 1959 by the American Society of Heating and Air-Conditioning Engineers, Inc., New York, N. Y. 768 p., $8^3/_4 \times 11^1/_4$ in., bound. $12. A revised edition of a standard handbook which covers environment, comfort, and physiological principles; heating and cooling loads; room heating and cooling methods and equipment; air systems and equipment; steam and water systems and equipment; heat generating methods and equipment; refrigeration, spray apparatus, and sorbents; controls, instruments and motors; and industrial systems. Five new chapters have been added on high-temperature water systems, the heat pump, evaporative apparatus for heat rejection, evaporative air cooling and humidification, and snow melting. In addition, extensive changes have been made throughout the volume. A feature of the guide is the extensive references provided with each chapter and a separately paged buyer's guide of over four hundred pages.

Information Theory and Statistics
By Solomon Kullback. 1959, John Wiley and Sons, Inc., New York, N. Y. 395 p., $6 \times 9^1/_4$ in., bound. $12.50. Discusses logarithmic measures of information and their application to the testing of statistical hypotheses. Throughout the book there is an attempt to maintain consistency in the application of the concepts and properties of information theory so as to achieve a unified presentation of the subject matter. Specific applications considered include analysis of samples of fixed size, analysis of multinomial samples, and of samples from Poisson populations, and analysis of contingency tables. Also included are parametric problems about the exponential family of populations, particularly the multinomial, Poisson, and normal.

LIBRARY SERVICES

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Interkama, 1957
Vorträge zum Internationalen Köngress mit Austellung für Messtechnik und Automatik. Published 1958 by R. Oldenbourg, Munich, Germany. Various pagings, $8^1/_2 \times 11^3/_4$ in., bound. 38.80 DM. This collection brings together the more than 75 papers presented at an international conference on measuring techniques and automatic control held in Düsseldorf in 1957. The areas covered are electrical and process-control measuring instruments, processes of measurement, control apparatus and methods in communication engineering, power control of boilers for compounding, and automatic control for batch processing. The papers are in German, often with English summaries, and most have appeared previously in various other German publications.

Introduction to the Theory of Compressible Flow
By Shih-I Pai. 1959, Van Nostrand Company, Inc., Princeton, N. J. 385 p., $6^1/_2 \times 9^1/_4$ in., bound. $9.75. The fundamentals of compressible flow are described, ranging from basic assumptions and formulation of theory to various methods of solving the problems involved. The physical properties of gases are reviewed and followed by a detailed discussion of the theory of compressible flow of inviscid fluids in relation to both steady and non-steady flow. In addition, such advanced topics as transonic flow, hypersonic flow, and rotational flow are thoroughly examined. In the last three chapters the author provides a detailed analysis of a viscous compressible fluid including the effect of chemical reaction and electromagnetic forces.

Jets and Rockets
By A. Barker and others. 1959, Chapman and Hall, London, England. 268 p., $5^1/_2 \times 8^1/_2$ in., bound. 35s. The close relationship of rocket and jet development to advances in high-speed aerodynamics forms the underlying theme of this volume, which approaches the subject of aircraft propulsion from the viewpoint of the aerodynamicist. Among those topics discussed are the momentum theory of jet and rocket propulsion, air resistance, and aerodynamic design at high speeds, the performance of rocket projectiles, and future developments. Numerous illustrations are provided and appendixes with useful data are included.

Materials for Rockets and Missiles
By R. G. Frank and W. F. Zimmerman. 1959, The Macmillan Company, New York, N. Y. 124 p., $5 \times 7^1/_2$ in., bound. $4.50. Presents typical engineering data on lightweight, high-temperature materials. Existing metal and ceramic materials are surveyed and those materials which are expected to become available during the next few years are indicated. Materials are compared according to their chemistries and selected physical properties such as density, coefficients of thermal expansion and conductivity, elastic moduli, and impact strength. New material fabrication processes, including high-temperature brazing, chipless production, and unconventional machining techniques are also covered. Sheet, wrought, and cast alloys with iron, nickel, and cobalt bases are covered, as are wrought and cast alloys of aluminum and magnesium, titanium alloys, cermets, molybdenum alloys, and ceramics.

Mechanical Design and Analysis
By R. R. Slaymaker. 1959, John Wiley and Sons, Inc., New York, N. Y. 418 p., $6 \times 9^1/_4$ in., bound. $9.50. The major part of the book consists of wide and recent selection of industrial case studies in machine design. The author's intent is to relate the text to specific design situations where the problem precedes the theory, and may be solved in a variety of ways. An analysis pertinent to each problem is given, providing a clear and co-ordinated background. Review material for the most part has been omitted, but certain topics which may have been included in more elementary texts have been covered. These are limit dimensioning, materials to match job requirements, and repeated stress effects.

Mechanics—Part 2: Dynamics
By J. O. Meriam. Second Edition. 1959, John Wiley and Sons, Inc., New York, N. Y. 420 p., $6 \times 9^1/_4$ in., bound. $5. Among those aspects of the subject covered are kinematics; kinetics; force, mass, and acceleration; impulse and momentum; and periodic motion. Appendixes deal with vector methods and moments of inertia. In the present edition of this work various changes have been made to make the book more useful. Greater distinction is made between absolute and relative motion analysis in the chapter on kinematics, and greater emphasis is placed on the formulation of problems in particle kinetics by means of the differential equation of motion. In the treatment of work and energy a new section on virtual work is included which not only helps in solving certain types of problems but provides a steppingstone to advanced theory.

Standard Methods for Testing Petroleum and Its Products
Published 1959 by the Institute of Petroleum. Eighteenth Edition. 835 p., $5^1/_2 \times 8^1/_2$ in., paper. 2£. Includes standards on all phases of testing petroleum and its products with the exception of engine test methods for rating fuels. New methods included are analysis by gas chromatography of petroleum gases, determination of flash point of petroleum products by the Abel apparatus, penetration of semifluid greases, and evaluation of lubricating greases.

Current Engineering Events, News, and Comment

E. S. NEWMAN
News Editor

THE ROUNDUP

Trends in Technical Institute Enrollment . . .

. . . revealed in EJC study of recent enrollment in technical institutes offering ECPD accredited curriculums

In early 1959 the Engineering Manpower Commission of Engineers Joint Council, in co-operation with The American Society for Engineering Education, made a study of trends in freshman engineering enrollment. (See Mechanical Engineering, July, 1959, p. 33.) The primary objective was to evaluate the contributory causes of the drop in freshman engineering enrollment in the fall of 1958.[1]

Many of the factors identified in the study suggested that some relation might exist between freshman enrollments in engineering colleges and first-year enrollments in less than baccalaureate programs. EMC undertook, in June, a survey to evaluate trends in technical institutes that offered Engineers' Council for Professional Development accredited curriculums.

Summary and Conclusions. According to the report 1958 first-year enrollments in ECPD accredited technical institutes increased over 1957 (by 1.2 per cent). This rise, however, was substantially smaller than the increase experienced in 1957 (10.2 per cent over 1956).

Diversion of technically oriented students to other educational pursuits, observed in the engineering colleges, apparently occurred to a lesser extent in technical institutes. There does not appear to be any gain in the two-year program enrollments at the expense of the engineering colleges.

Less than one third of the institutes reported receiving a lower number of applications from qualified candidates. Although entrance requirements are being tightened in some institutes, it is suggested that enrollment is not measurably affected, but rather that the number and quality of those completing the programs will increase.

Less than 30 per cent of the institutes accepted a smaller number of applicants for 1958 enrollment, compared with their 1957 experience. This proportion appears to correspond to the fraction reporting a reduced number of applications.

Over-all first-year technical institute enrollment is expected to increase in the fall of 1959. Close to half of the institutes anticipate increasing enrollment significantly and the balance expect about the same enrollment, except for 5 per cent who foresee a smaller number.

Officers of the Institutes report increased industrial recognition of the potentials of engineering technicians in important supporting roles to engineers; the institutes are showing a corresponding concern for increased quality of their graduates.

Responding Sample. Survey questionnaires were mailed to 34 technical institutes that currently offer at least one two-year curriculum accredited by ECPD. Questionnaires were received from 29. In addition, three others indicated they were unable to provide the information.

The 29 institutes reported a total enrollment in 1958 of 20,367 full and part-time students. This compares with a total of 24,363 students in 35 (EMC surveyed 34 institutes; since one institute has recently changed its two-year program to a four-year baccalaureate grant program) institutes reported in ASEE's survey of technical institutes.[2] The EMC sample, therefore, represents between 85 and 90 per cent of the total enrollment of ECPD institutes. The latter, in turn, accounts for more than 30 per cent of enrollments in all institutions offering engineering technician programs, identified in the ASEE study.

Some respondents were not able to provide complete data for first and second-year enrollment and degrees for the three consecutive years requested—1956, 1957, and 1958. The statistics are, therefore, based on a more limited sample. The 26 institutions that furnished first-year data accounted for about 78 per cent of total enrollment, whereas the 22 institutes with complete data for all questions represent 63 per cent of the total ECPD technical institute enrollment in 1958.

[1] "Trends in Freshman Engineering Enrollment—1957, 1958, 1959," published by Engineering Manpower Commission, April 30, 1959.

[2] Donald C. Metz, Chairman, Manpower Studies, Technical Institute Division, ASEE, "Fourth Engineering Technician Survey of Enrollments and Graduates."

NBS Instrumentation Studies Reported at Cryogenic Engineering Conference

A report on National Bureau of Standards instrumentation studies carried out for a nuclear-powered rocket test program was one of the high lights during the Fifth Annual Cryogenic Engineering Conference. At the meeting, September 2–4, 1959, at the University of California, Berkeley, Calif., members of the staff of the NBS Cryogenic Engineering Laboratory (CEL) presented the results of their work in liquid-hydrogen-flow measurement, helium-liquefaction studies, and in investigating the strength properties of various structural magnesium alloys and adhesives.

A classical device, used for measuring or controlling fluid flow, has found its way into low-temperature hydrogen-transfer techniques. Called a Venturi meter, it has been widely used for ordinary fluids for many years. Now, for the first time, this instrument has demonstrated its value in cryogenic engineering. As shown by the investigators, J. R. Purcell, A. F. Schmidt, and R. B. Jacobs,

the Venturi meter will measure liquid hydrogen-flow rates ranging from nine to 270 gpm (34 to 1002 liters) with outstanding accuracy. In discussing the experimental work that was done to evaluate the Venturi as a cryogenic fluid meter, Purcell did not fail to mention the comparison between the device's accuracy and its low cost.

"Cost was an important consideration," commented D. B. Mann, engineer in CEL's Cryogenic Processes section, "in our design of a laboratory-size helium liquefier." The use of available cryogenic liquids, hydrogen and nitrogen, as precoolants, eliminated the need for moving parts and thus for periodic maintenance. The designers, W. R. Bjorkland, J. Macinko, M. J. Hiza, and Mann, have found that this liquefier, one of the simplest of all constructed to produce liquid helium, performs according to the predictions of the design equations with respect to heat exchanger performance, liquefier capacity, and system pressure changes. In fact, the actual performance matches the theoretical one so closely that now this or a similar system's liquefaction reliability can be forecast with established confidence factors.

Two CEL studies were reviewed at the conference's session on mechanical properties. In assisting the Wright Air Development Center (WADC) in an extensive adhesives evaluation program, CEL examined ten commercial combinations of epoxy, vinyl, and phenolic resins at dry ice (−107 F) and liquid nitrogen (−323 F) and hydrogen (−424 F) temperatures.

"In general," said William Frost, physicist in CEL's Properties of Materials section, "the commercial adhesives I tested do decrease in strength at lower temperatures; however, some do show slight increases." Notable among the adhesives investigated were the epoxy-phenolics which, when filled and supported on glass cloth, exhibited the highest low-temperature strengths and showed almost constant strengths over the range of test temperatures.

The lightweight metal, magnesium, is under consideration as a missile and space vehicle construction material. How well does it stand up when subjected to low temperatures, down to about −425 F? According to R. P. Mikesell, CEL physicist, the six magnesium alloys that he, R. P. Reed, and R. L. Greeson investigated at cryogenic temperatures all compare favorably, on a strength-to-weight basis, with other materials having good low-temperature properties—stainless steel, nickel, and copper alloys. The investigators chose these six magnesium alloys because they were representative of all the magnesium alloys and their physical properties indicated them to be promising from a cryogenic viewpoint.

NAS-NRC Appoints Committee to Accelerate U. S. Materials Research and Development

Detlev W. Bronk, Hon. Mem. ASME, president of the National Academy of Sciences-National Research Council, announced recently the appointment of a 14-man committee to determine how materials research and development in the United States can be accelerated to meet the increasing demands of industrial progress and of national defense.

Several Academy-Research Council committees have concerned themselves for some time with various aspects of the national materials research program—that is, with regard to specific materials (steel and its alloys, the rarer metals, ceramics, and so on) and to the stimulation of more imaginative research in the broad field. These groups, in their long contact with others in the area, have become aware of a general and urgent concern as to the adequacy of the current national effort in materials research. Many individuals have warned that, without an immediate acceleration and considerable broadening of our understanding of materials and their processing, we shall be unable to meet the demands of present-day and anticipated design of industrial and military materiel.

Dr. Bronk stated that, in response to this widespread feeling that the problem was one of immediate concern, he had appointed the Committee on the Scope and Conduct of Materials Research to view the total materials research needs of the country with relation to the general public welfare. The Committee has been asked to determine how more rapid and effective progress in materials research can be realized through increased financial support, administrative or organizational steps, improved co-ordination of effort or other means; to consider both basic and applied research carried on for both defense and nondefense purposes in governmental, industrial, academic, and other research institutions; and to consider the resources of raw materials, personnel, and facilities.

Confederation of Engineering Profession in Canada

The Engineering Institute of Canada announced recently that, as a result of a plebiscite of its corporate members, who were eligible to vote, about 30 per cent cast ballots. Of these, about 95 per cent were in favor of continuing negotiations with the Canadian Council of Professional Engineers, with the object of joining a single national body that would consolidate these two organizations.

As a result of this vote, the Engineering Institute of Canada will now proceed, jointly with the Canadian Council of Professional Engineers, to establish the Engineers Confederation Commission. This new 25-man Commission will be charged with the responsibility of drawing up detailed proposals for a charter and bylaws for the suggested new national body. These proposals will then be submitted to the membership of both bodies for ratification.

PEOPLE

Honors and Awards. Lillian M. Gilbreth, Hon. Mem. ASME, the woman renowned for the role she played in helping businessmen apply scientific management principles in industry, has been named to receive the 1959 International Systems Award. It is a commemorative plaque and $1000 honorarium sponsored by the Systems Procedures Association.

The 1959 James Watt International Medal was posthumously awarded to the late Sir Claude Dixon Gibb, engineer, scientist, and administrator. The Gold Medal is awarded every two years by The Institution of Mechanical Engineers (Great Britain).

Robert G. Le Tourneau, Fellow ASME, has been named the recipient of the 1959 National Defense Transportation Association's Award. The "electric wheel" system for powering ultra-heavy-duty-equipment—ranging from gigantic rubber-tired trains for the Arctic to the world's largest road-building machines—is one of his many developments.

Samuel Glasstone, consultant to the

Los Alamos Scientific Laboratory, Los Alamos, N. Mex., has been named the recipient of the 1959 ASME Worcester Reed Warner Medal. The medal is awarded for an outstanding contribution to the permanent literature of engineering.

New Appointments. Robert E. Hollingsworth has been appointed Deputy General Manager of the U. S. Atomic Energy Commission. He has been on the AEC staff since 1947.

Campus News. Thomas H. Chilton, Mem. ASME, technical adviser to du Pont's Engineering Department and nationally renowned in academic and professional engineering circles, has retired from the company after 34 years in order to undertake a series of teaching assignments. The first of these is regents' professor in chemical engineering at the University of California, Berkeley, for the 1959–1960 academic year.

Nicholas A. Weil, Mem. ASME, has been named director of mechanical-engineering research at Armour Research Foundation of Illinois Institute of Technology, Chicago.

Robert R. White, associated dean of the College of Engineering and a professor of chemical and metallurgical engineering, has been named director of the University of Michigan's Institute of Science and Technology.

COMING MEETINGS

Nuclear Fuel Reprocessing

The U. S. Atomic Energy Commission, in co-operation with AEC contractors, will sponsor a two-day symposium for management and technical personnel on the reprocessing of nuclear fuels, in Richland, Wash., on Oct. 20-21, 1959. The symposium is designed to review the technology currently available for reprocessing spent fuels from research, test, and power reactors.

The symposium will be open to private reactor operators, fuel fabricators, AEC and AEC-Contractor personnel, foreign visitors, and certain other management and technical personnel.

For details write: Mr. J. T. Christy, Hanford Operations Office, U. S. Atomic Energy Commission, Richland, Wash.

Standards

The Tenth National Conference on Standards, to be held Oct. 20–22 at the Sheraton-Cadillac Hotel, Detroit, Mich., will concentrate on showing how standards help counteract the "profit squeeze."

The American Standards Association sponsors the conference annually as a means of calling national attention to the importance of standardization.

The Automobile Manufacturers Association, the Industrial Fasteners Institute, ASTE, and ASME, are among the groups who will participate in the conference as session sponsors.

Reactor Technology

Oak Ridge National Laboratory has announced that the Third Conference on Analytical Chemistry in Nuclear Reactor Technology will be held at Gatlinburg, Tenn., on Oct. 26–28, 1959.

The general theme of this conference, analysis of reactor materials following the operation of nuclear reactors, complements sequentially those of prior meetings which dealt with, (1) advances in the chemical analysis of important reactor materials, and (2) the role of analytical chemistry in the start-up and operation of nuclear reactors.

The subjects which will be emphasized at this conference are: Chemical analysis as related to the estimation of corrosion and erosion rates, reprocessing of fuels and blanket materials, and the analytical chemistry of fission product mixtures, of plutonium, and of the transplutonic elements.

Gas-Lubricated Bearings

The Office of Naval Research will hold a symposium on Gas-Lubricated Bearings, Oct. 26–28, 1959, Washington, D. C. It will be the first meeting devoted exclusively to broad international scientific coverage of gas-lubricated bearings.

The symposium will attempt to cover all aspects of the subject—theoretical and experimental research, design, production, and application. Papers have been invited from authoritative contributors, to the field, throughout the world.

Inquiries should be addressed to Power Branch, Office of Naval Research, Washington 25, D. C., or to Prof. D. D. Fuller, The Franklin Institute Laboratories for Research and Development, Philadelphia 3, Pa.

Metals Casting

The Purdue Metals Casting Conference will be held Oct. 29–30, 1959, on the Purdue University campus. Sessions are scheduled for representatives of ferrous and nonferrous foundries, and specific topics have been arranged for each type of foundry operation. For details write: K. E. Clancy, Senior Conference Coordinator, Purdue University, Lafayette, Ind.

Instrumentation

The Eighth Annual Instrumentation Conference will be held Nov. 5–6 at the Louisiana Polytechnic Institute, School of Engineering, Ruston, La. Six papers covering different aspects of instrumentation are to be presented and there will be exhibits of new equipment in instrumentation and process control.

Industrial Fasteners

"Industrial Fastener Applications" will be the subject of a two-day Engineering Institute sponsored by the University of Wisconsin Extension Division in co-operation with the College of Engineering. The meeting will be held at the New Wisconsin Center Building, Nov. 19–20. Fee for the conference is $25.

INDUSTRIAL FILMS

Silicone Stories

"More Muscles for Tomorrow" and "Rubber From Rock," are two 16-mm, sound, color films issued recently by the Dow Corning Corporation.

"More Muscles for Tomorrow" shows how silicone electrical insulation saves space and weight, outperforms organic materials, and saves production and maintenance dollars.

"Rubber from Rock" describes the complete technical story of Silastic, a silicone rubber. It shows how Silastic is made, what performance can be expected, and how it can be used.

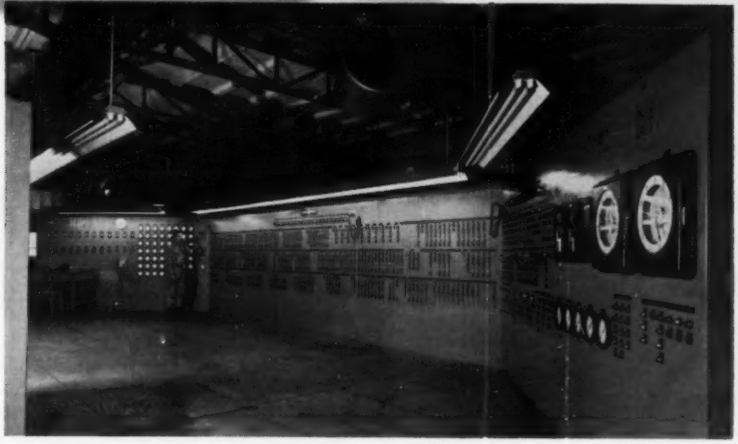
To arrange for a showing, write Dow Corning Corporation, Midland, Mich.

Axial-Piston Pumps

"Design for Power," a new 16-mm, sound, color film on the advantages of axial-piston pumps in high-pressure hydraulics, is now available from Denison Engineering Division, American Brake Shoe Company.

The advantages of axial-piston pumps on heavy-duty press equipment, mobile machinery, ground support and marine power systems, at pressures up to and above 5000 psi, are analyzed.

A descriptive folder and order blank may be obtained from Denison Engineering Division, American Brake Shoe Company, 1160 Dublin Road, Columbus 16, Ohio.



Push-button coal cleaning in one of the largest, most highly automated plants of its type in the world is shown in Link-Belt Company's latest 16-mm film, "Preparation Makes the Product." This new plant of the Clinchfield Coal Company, division of The Pittston Company, has a capacity of 1500 tons of coal an hour. The film is available without cost, on letterhead request for showing in the U. S., from Link-Belt Company, Department PR, Prudential Plaza, Chicago 1, Ill.

Electric Motors

"Motors in the Making," a 16-mm, sound, color movie, has just been released by Wagner Electric Corporation.

The film shows, step-by-step, the processes in the manufacture of electric motors including frame fabrication, stator winding, rotor casting and winding, assembly, testing, and packing for shipment. A series of scenes describes the testing of materials, tools, and instruments used in the manufacturing operations.

This film may be borrowed free of charge for showing to industrial, commercial, engineering, and educational groups. For further information, write Mr. L. C. Dobrunz, Sales Promotion Manager, Wagner Electric Corporation, St. Louis 33, Mo.

How Research and Development Fits Into Nation's Budget

Research and development budgets in close to 600 U. S. corporations are 12 per cent higher this year than 1958's record outlay, according to a survey released by the American Management Association. A total of 64 per cent of the firms studied increased their budgets for the development of new products and processes, 8 per cent were unchanged, and 28 per cent reduced budgets.

Results of AMA's annual analysis of R&D budgets, were disclosed at an AMA management forum for company presidents meeting at the Hotel Astor, New York City. Last year's survey showed R&D budgets to be only 4 per cent higher than in 1957.

Among the 23 industry groups studied, automobiles were on top with a 32 per cent increase over last year. Three other industries had budget hikes of better than 20 per cent (electrical machinery, 23.8 per cent; instruments, 29.7 per cent; and metalworking machinery, 21.7 per cent). Only one group—miscellaneous machinery and parts—showed a decline; in 1958 six groups had a net budget decrease, including this group.

New product expenditures in 1958 averaged 3.2 per cent of the sales dollar that year, compared with 2.8 per cent in 1957. The rubber industry topped all other groups with an R&D budget totaling 9.3 per cent of industry sales. Next came general industrial machinery with 7 per cent and a fair sprinkling of industries spending better than 4 per cent (instruments, 4.8 per cent; chemicals, 4.3 per cent; and electrical machinery, 4.1 per cent).

The AMA analysis has been developed to assist companies in formulating guide lines for the charting of their corporate growth programs. It provides some indication of the relative shift in emphasis that will be reflected ultimately in new products in selected industrial groups.

Product-development activities today have a greatly magnified multiplying effect on earnings, according to an AMA spokesman. New products tend to produce added profits and part of these can be made available for expanded development programs. "Corporations that are ahead usually stay ahead and it is becoming increasingly difficult for late starters to catch up," he told the 60 company presidents attending the AMA forum.

"The really big achievements will depend more on technological capabilities and the use of technology than on the mere spending of more money. The expenditure of less money can often yield greater returns, if spent wisely and effectively," he added, commenting on the need for better management of technology.

"Those corporations that can capture leadership positions in the use of new technology within specific industries can command their destinies, both with respect to directions taken and profit levels achieved," he concluded. "Technology is the arch foe of established order and procedure. While it creates radically new opportunities, it also creates changing conditions that call for sweeping reappraisals of management thinking and action patterns if management is to turn new technology into profits."

AMA Annual Analysis of Research and Development Budgets—1959

Industry Group	Number of Companies Report: Total	Number up	Number same	Number down	Average 1959 R&D Budget Increase Over 1958 (%)	1958 R&D Budget % of 1958 Sales
Agricultural Machinery	4	4	—	—	8.8	2.6
Aircraft	12	7	2	3	6.7	3.3
Automobiles	5	5	—	—	32.1	2.8
Chemicals	154	103	8	43	11.3	4.3
Electrical Machinery	40	27	3	10	23.8	4.1
Engines & Turbines	5	3	—	2	2.8	2.0
Fabricated Metal Products	38	19	5	14	5.7	1.7
Food & Beverages	47	36	1	10	10.8	.9
General Industrial Machinery	19	15	2	2	16.3	7.0
Instruments	42	25	3	14	29.7	4.8
Metalworking Machinery	3	2	—	1	21.7	3.2
Miscellaneous Machinery & Parts	9	3	3	3	(−2.5)	3.1
Miscellaneous Manufacturing	68	44	6	18	9.6	2.8
Nonferrous Metals	21	11	2	8	12.4	1.3
Office Machinery	9	8	1	—	13.0	3.0
Paper	26	17	4	5	11.6	.9
Petroleum Refining	19	12	5	2	1.4	1.2
Rubber	12	6	—	6	6.6	9.3
Service Machinery	1	1	—	—	6.0	1.9
Steel	12	5	1	6	2.4	1.1
Stone Clay & Glass	22	13	1	8	7.2	2.1
Textiles	10	3	1	6	10.3	1.4
Transportation Equipment	4	2	—	2	7.5	2.2
TOTALS	582	371	48	163	12.1	3.2

UEC BUILDING FUND—Member Gifts Campaign Status

(As reported on September 11, 1959)

Society	Quota	Subscriptions	Number of Subscribers	Per Cent of Quota
ASCE	$800,000	$ 575,707.99	9,975	71.9
AIME	500,000	306,441.98	4,685	61.2
ASME	800,000	558,922.82	11,493	69.8
AIEE	900,000	786,338.31	20,945	87.6
AIChE	300,000	302,519.36	7,335	100.7
AICE	80,000	20,818.33	42	26.1
AIIndE	70,000	47,668.00	1,780	68.2
SWE	7,000	2,524.50	16	36.0
AWS	60,000	7,079.17	62	11.8
ASHRAE	...	551.50	25	..
IES	...	229.50	16	..
Other	...	7,027.91	186	..
Total		$2,615,829.37	56,560	

MEETINGS OF OTHER SOCIETIES

Oct. 19–21

AIEE, machine tool conference, Hotel Cleveland, Cleveland, Ohio.

Oct. 19–23

ASCE, annual convention, Statler-Hilton Hotel, Washington, D. C.

Oct. 20–22

NACE, fourth annual corrosion conference, Statler-Hilton Hotel, Cleveland, Ohio.

Oct. 20–22

ASA, national conference on standards, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 21–23

Society for Experimental Stress Analysis, annual meeting, Pick-Fort Shelby Hotel, Detroit, Mich.

Oct. 26–28

Office of Naval Research–The Franklin Institute, first international symposium on gas lubricated bearings, Shoreham Hotel, Washington, D. C.

Oct. 28–29

Armour Research Foundation, annual computer conference, Morrison Hotel, Chicago, Ill.

Nov. 2–4

Atomic Industrial Forum, annual conference, Sheraton-Park Hotel, Washington, D. C.

Nov. 2–6

AIME, fall meeting, Morrison Hotel, Chicago, Ill.

Nov. 2–6

Society for Nondestructive Testing, 19th annual convention, Hotel Hamilton, Chicago, Ill.

Nov. 4–6

American Nuclear Society, Sheraton-Park Hotel, Washington, D. C.

Nov. 9–11

API, annual meeting, Conrad Hilton, Palmer House, and Pick Congress Hotels, Chicago, Ill.

Nov. 9–11

Steel Founders' Society of America, technical and operating conference, Carter Hotel, Cleveland, Ohio.

Nov. 9–13

NEMA, Traymore Hotel, Atlantic City, N. J.

Nov. 11–14

SNAME, annual meeting, Waldorf-Astoria Hotel, New York, N. Y.

Nov. 12–13

Operations Research Society of America, national meeting, Huntington-Sheraton Hotel, Pasadena, Calif.

Nov. 16–20

American Rocket Society, annual meeting, Sheraton-Park Hotel, Washington, D. C.

Nov. 16–20

Fifth International Automation Congress and Exposition, New York Trade Show Building, New York, N. Y.

(*For ASME Coming Events, see page 131.*)

EDUCATION

Columbia Expands Science Honors Program

Columbia University's first year of its Science Honors Program for gifted high-school students—sponsored by the University's School of Engineering—has won such high praise from faculty, students, and their high schools, that this Fall it is to be expanded.

Under the direction of the Columbia-sponsored Joint Program for Technical Education, college-level classes were taught by the University faculty as a contribution to the enrichment of high-school education. The courses were designed to constitute a pilot program to demonstrate how far and fast science education can take pupils at this level, and to explore new teaching techniques.

Each Saturday during the term, certain students were invited to lunch at the Faculty Club with many of the distinguished Columbia scientists, including Nobel Prize winners.

The program has been made possible by grants from the Hebrew Technical Institute and the Fund for the Advancement of Education of the Ford Foundation.

AEC Grants $12,000 for Course at Stevens

A $12,000 grant to establish the first undergraduate course in nuclear engineering at Stevens Institute of Technology has been awarded to the college by the Atomic Energy Commission.

The grant will help equip a nuclear laboratory at Stevens for the new course to be given in the fall by the chemistry-chemical engineering department. Proposals for the additional funds needed to complete the laboratory have been submitted to the A.E.C.

Students view "scientists at work" series developed by Eastman Kodak as an aid to teachers in science classrooms. The series is available on loan and is intended to stimulate student interest in science and engineering.

Notes on Society Activities and Events

E. S. NEWMAN
News Editor

THE ASME NEWS

Engineering—Pathway to a Better Tomorrow

Theme of 1959 ASME Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

High Lights of the 1959 Annual Meeting

SUNDAY, NOVEMBER 29

4:00 p.m. "Early Bird" Party

8:30 p.m. Hotel Concert

MONDAY, NOVEMBER 30

12:15 p.m. President's Luncheon

Presentation:
Melville Medal
Worcester Reed Warner Medal
Holley Medal
John Fritz Medal
Address: *Glenn B. Warren*, President, ASME

4:45 p.m. Business Meeting

8:00 p.m. Variety Show and Dancing

TUESDAY, DECEMBER 1

9:30 a.m. Trip to National Aviation Facilities Experimental Center

12:15 p.m. Fuels Luncheon

Presider: *C. F. Kottcamp*, chief fuels and lubricants engineer, Gulf Research & Development Co., Pittsburgh, Pa.
Speaker: *A. R. Matthews*, president, Consolidation Coal Co., Pittsburgh, Pa.
Subject: **Coal for Power**

12:15 p.m. Management Luncheon and Towne Lecture

Presider: *C. A. Jurgensen*, vice-president, De Laval Steam Turbine Co., Trenton, N. J.
Lecturer: *Lieut. General James M. Gavin*, executive vice-president, Arthur D. Little, Inc., Cambridge, Mass.
Subject: **The Challenge of the 60's**

12:15 p.m. Metals Engineering Luncheon

Toastmaster: *M. J. Manjoine*, Mechanics Department, Westinghouse Research Laboratories, Pittsburgh, Pa.
Speaker: *Francis G. Tatnall*, vice-president, Tatnall Measuring Systems Co., Phoenixville, Pa.
Subject: **What the Mechanical Engineer Said to the Materials Engineer**

12:15 p.m. Petroleum Luncheon

Presider: *T. L. White*, consultant, The Commercial Shearing & Stamping Co., Youngstown, Ohio
Speaker: *Clarence H. Thayer*, vice-president in charge of manufacturing, Sun Oil Co., Philadelphia, Pa.
Subject: **Plants, Processes, and People—Tomorrow**

4:00 p.m. Tea Dance

6:00 p.m. Applied Mechanics Dinner

Toastmaster: *William Prager*, L. Herbert Ballou University Professor, Brown Univ., Providence, R. I.
Introduction: *Jerome C. Hunsaker*, professor, Department of Aeronautics, Massachusetts Institute of Technology, Cambridge, Mass.
Presentation of Timoshenko Medal to *Prof. Sir Richard V. Southwell*, Rector, Imperial College of Science and Technology, University of London, London, England
Response: Recipient of Timoshenko Medal
Address: *The Honorable Joseph V. Charyk*, Assistant Secretary of the Air Force, Research and Development, Washington, D. C.

6:00 p.m. Hydraulic Dinner

Toastmaster: *J. Robert Groff*, president and general manager, The James Leffel & Co., Springfield, Ohio
Speaker: To be announced
Subject: **Guided Missile Developments**

9:00 p.m. Bridge Party

WEDNESDAY, DECEMBER 2

9:00 a.m. Trip: Owens-Illinois Glass Co., Bridgeton, N. J.

12:15 p.m. Heat Transfer Luncheon

Presider: *William E. Hammond*, vice-president, Air Preheater Corp., Wellsville, N. Y.
Address: *Rear Admiral M. J. Lawrence*, USN, Assistant Chief, Bureau of Ships, Washington, D. C.

12:15 p.m. Machine Design Luncheon

Presider: *C. W. Besserer*, assistant program director, Minuteman Program, Space Technology Labs, Los Angeles, Calif.
Presentation: Machine Design Medal
Address: *Charles E. Crede*, associate professor of mechanical engineering, California Institute of Technology, Pasadena, Calif.

8:00 p.m. Movie Night

THURSDAY, DECEMBER 3

10:30 a.m. Trip to Brighton Florists, Linwood, N. J.

12:15 p.m. Members and Students Luncheon

Presentation:
Pi Tau Sigma Gold Medal Award
Richards Memorial Award
Undergraduate Student Award
Charles T. Main Award
Old Guard Prize

6:00 p.m. Social Hour

7:00 p.m. Banquet

Conferral of Honorary Memberships
Speaker: *Marcus Long*, professor of

philosophy, University of Toronto, Toronto, Ont., Canada
Subject: **Engineers Are People?**

10:00 p.m. Dance

FRIDAY, DECEMBER 4

12:15 p.m. Textile Engineering Luncheon

Presider: *V. F. Sepavich*, manager, Research and Development, Crompton & Knowles Corp., Worcester, Mass.
Speaker: *D. H. McMillan*, sales representative—User Sales, Small AC Motor & Generator Dept., General Electric Co., Schenectady, N. Y.
Subject: **Value Analysis as a Means for Profit**

AIR POLLUTION CONTROLS SESSION

I MONDAY, NOVEMBER 30 2:30 p.m.

Control of Air Pollution From Oil-Burning Power Plants, by *H. C. Austin* and *W. L. Chadwick*, Southern California Edison Co. (Paper No. 59—A-71)

Effect of Operating Variables on the Stack Emission From a Modern Power-Station Boiler,[1] by *G. C. Jefferis*, Philadelphia Elec. Co. and *J. D. Sensenbaugh*, Combustion Engrg., Inc.

Diffusion of Gaseous Pollutants From Industrial Stacks Over an Urban Area,[1] by *R. I. Larsen* and *R. A. McCormick*, U. S. Public Health Service

APPLIED MECHANICS SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Elasticity

A Photoelastic Approach to Transient Stress Problems Employing Low Modulus Materials, by *J. W. Dally*, Cornell Univ., *W. F. Riley* and *A. J. Durelli*, Armour Research Foundation (Paper No. 59—A-10)

Plane-Stress Unloading Waves Emanating From a Suddenly Punched Hole in a Stretched Elastic Plate, by *Julius Miklowitz*, California Inst. of Tech. (Paper No. 59—A-46)

Stresses in a Slab Having a Spherical Cavity Under Circular Bending,[2] by *Chih-Bing Ling* and *Chen-Peng Tsai*, Aeronautical Research Lab., Taiwan (Formosa), China (Paper No. 59—A-64)

Thermal Stresses Owing to a Hot Spot in a Rectangular Strip,[2] by *C. W. Nelson*, International Business Machines Corp. (Paper No. 59—A-8)

Elastic Equilibrium of a Plate With a Reinforced Elliptical Hole, by *Eugene Levin*, The RAND Corp. (Paper No. 59—A-45)

[1] Paper available at Meeting.
[2] Not presented orally.

Official Notice

ASME Business Meeting

The Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held on Monday afternoon, Nov. 30, 1959, at 4:45 p.m., at the Chalfonte-Haddon Hall, Atlantic City, N. J., as part of the Annual Meeting of the Society.

Members are urged to attend.

Transient Thermal Stresses in a Semi-Infinite Slab, by *Eli Sternberg*, Brown Univ., and *W. Jaunzemis*, The Pennsylvania State Univ. (Paper No. 59—A-63)

A Method of Solution for the Elastic Quarter-Plane, by *M. Hetényi*, Northwestern Univ. (Paper No. 59—A-92)

The Half-Space Under Pressure Distributed Over an Elliptical Portion of Its Plane Boundary,[2] by *H. Deresiewicz*, Columbia Univ. (Paper No. 59—A-17)

II MONDAY, NOVEMBER 30 2:30 p.m.

Structures

Shear Buckling of Bars, by *G. Herrmann*, Columbia Univ., and *A. E. Armenakas*, Cooper Union for the Advancement of Science and Art (Paper No. 59—A-91)

On the Optimum Design of Shells,[2] by *R. T. Shield*, Brown Univ. (Paper No. 59—A-47)

Correlation of Theoretical and Photothermoelastic Results on Thermal Stresses in Idealized Wing Structures,[2] by *George Gerard* and *Herbert Tramposch*, New York Univ. (Paper No. 59—A-36)

Effect of Shear Deformations on the Bending of Rectangular Plates, by *V. L. Salerno*, Fairleigh Dickinson Univ., and *M. A. Goldberg*, Grumman Aircraft Engrg. Corp. (Paper No. 59—A-66)

Stresses in an Ellipsoidal Rotor in a Centrifugal Force Field, by *M. A. Goldberg*, Grumman Aircraft Engrg. Corp., and *Michael Sadowsky*, Rensselaer Polytechnic Inst. (Paper No. 59—A-4)

Heat-Exchanger Tube-Sheet Design-3. U-Tube and Bayonet Tube Exchangers, by *K. A. Gardner*, Yuba Consolidated Industries, Inc. (Paper No. 59—A-81)

The Approximate Analysis of Certain Boundary-Value Problems, by *H. D. Conway*, Cornell Univ. (Paper No. 59—A-80)

III TUESDAY, DECEMBER 1 9:30 a.m.

Colloquium on Structural Damping

Energy-Dissipation Mechanisms in Structures, With Particular Reference to Material Damping,[3] by *B. J. Lazan*, Univ. of Minnesota

Review of Progress in Analysis of Interfacial Slip Damping,[3] by *L. E. Goodman*, Univ. of Minnesota

Damping of Plate Flexural Vibrations by Means of Viscoelastic Laminae,[3] by *Donald Ross*, *E. E. Ungar*, and *E. M. Kerwin, Jr.*, Bolt Beranek & Newman, Inc.

Vibrational-Energy Dissipation at Structural Support Junctions,[3] by *T. J. Mentel*, Univ. of Minnesota

Measurement of Damping,[3] by *Robert Plunkett*, Gen. Elec. Co.

Material Design for Resonant Members,[3] by *Joseph Marin* and *M. G. Sharma*, The Pennsylvania State Univ.

IV TUESDAY, DECEMBER 1 2:30 p.m.

Plasticity

Strain-Hardening Solutions to Axisymmetric Disks and Tubes, by *Nicholas Perrone*, Pratt Inst. (Paper No. 59—A-29)

Stresses in the Plastic Range Around a Normally Loaded Circular Hole in an Infinite Sheet,[2] by *O. L. Mangasarian*, Shell Development Co. (Paper No. 59—A-130)

Mechanics of the Sheet-Bending Process, by *B. W. Shaffer*, New York Univ. and *E. E. Ungar*, Bolt Beranek & Newman, Inc. (Paper No. 59—A-35)

Relaxation of a Cylinder on a Rigid Shaft,[2] by *E. A. Davis*, Westinghouse Research Labs. (Paper No. 59—A-31)

Earth Motion Beneath a Prescribed Boundary Displacement, by *R. C. Geldmacher*, *J. W. Dunkin*, and *R. L. Anderson*, Purdue Univ. (Paper No. 59—A-3)

On the Plastic Behavior of Rotating Cylinders, by *Frederick Rimrott*, Nat. Research Council of Canada, Ecole Polytechnique, Montreal, Que., Canada (Paper No. 59—A-65)

[3] A bound volume, consisting of all papers presented at this session, will be available for purchase at the Technical Papers Desk and Publications Display Booth in Chalfonte-Haddon Hall during the meeting. These papers will not be published as separate papers nor will they be published in any other form.

V WEDNESDAY, DEC. 2 9:30 a.m.

Plasticity

On the Plastic Flow of Coulomb Solids Beyond Original Failure,[2] by *A. W. Jenike*, Univ. of Utah, and *R. T. Shield*, Brown Univ. (Paper No. 59—A-7)

Yield Conditions for Rotationally Symmetric Shells Under Axisymmetric Loading, by *P. G. Hodge, Jr.*, Illinois Inst. of Tech. (Paper No. 59—A-129)

Thermal Stress in a Viscoelastic Plastic Plate With Temperature Dependent Yield Stress, by *H. G. Landau* and *J. H. Weiner*, Columbia Univ., and *E. E. Zwicky, Jr.*, Gen. Elec. Co. (Paper No. 59—A-33)

Nonlinear Creep Deformations of Columns of Rectangular Cross Section, by *H. H. Bleich*, Columbia Univ., and *O. W. Dillon, Jr.*, The Johns Hopkins Univ. (Paper No. 59—A-1)

The Contact Problem for Viscoelastic Bodies, by *E. H. Lee*, Brown Univ., and *J. R. M. Radok*, Polytechnic Inst. of Brooklyn (Paper No. 59—A-83)

VI WEDNESDAY, DEC. 2 2:30 p.m.

Vibrations

Transient Analysis of Stess-Wave Penetration in Plates,[2] by *Norman Davids*, The Pennsylvania State Univ. (Paper No. 59—A-16)

Steady State Undamped Vibrations of a Class of Nonlinear Discrete Systems, by *P. R. Sethna*, Univ. of Minnesota (Paper No. 59—A-67)

Plastic-Wave Propagation Effects in Transverse Impact of Membranes, by *E. T. Onat* and *B. Karunes*, Brown Univ. (Paper No. 59—A-128)

Axially Symmetric Extensional Vibrations of a Circular Disk With a Concentric Hole,[2] by *O. G. Gustafsson*, SKF Industries, Inc., and *T. R. Kane*, Univ. of Pennsylvania (Paper No. 59—A-32)

The Elastic-Plastic Response of Thin Spherical Shells to Internal-Blast Loading, by *W. E. Baker*, Ballistic Research Labs., Aberdeen Proving Ground, Md. (Paper No. 59—A-95)

Dispersion of Flexural Waves in Elastic Circular Cylinder, by *R. D. Mindlin* and *Yih-Hsing Pao*, Columbia Univ. (Paper No. 59—A-84)

On a Dynamical Saint-Venant Principle,[2] by *B. A. Boley*, Columbia Univ. (Paper No. 59—A-61)

Classical Normal Modes in Damped Linear Dynamic Systems,[2] by *T. K. Caughey*, California Inst. of Tech. (Paper No. 59—A-62)

Normal Modes of Nonlinear Dual-Mode Systems, by *R. M. Rosenberg*, Univ. of California (Paper No. 59—A-93)

Subharmonic Oscillations of a Pendulum, by *Richard Skalak*, Columbia Univ., and *M. I. Yarymovych*, AVCO Research and Advanced Development Div. (Paper No. 59—A-94)

VII WEDNESDAY, DEC. 2 8:00 p.m.

Hydrodynamics and Lubrication

Production of Rotation in a Confined Liquid Through Translational Motion of the Boundaries,[2] by *R. R. Berlot*, Giannini Controls Corp. (Paper No. 59—A-15)

On the Indeterminateness of the Boundary Conditions for the Mixing of Two Parallel Streams, by *K. T. Yen*, Rensselaer Polytechnic Inst. (Paper No. 59—A-68)

Possible Similarity Solutions in Laminar-Free Convection on Vertical Plates and Cylinders, by *Kwang-Tzu Yang*, Univ. of Notre Dame (Paper No. 59—A-86)

Hydrodynamic Entrance Lengths for Incompressible Laminar Flow in Rectangular Channels, by *L. S. Han*, Ohio State Univ. (Paper No. 59—A-82)

VIII THURSDAY, DEC. 3 9:30 a.m.

Vibrations

On the Elastic Bending of Columns Due to Dynamic Axial Forces Including Effects of Axial Inertia, by *Eugene Sevin*, Armour Research Foundation (Paper No. 59—A-25)

Stability of Forced Oscillations With Nonlinear Second-Order Terms, by *Chi-Neng Shen*, Rensselaer Polytechnic Inst. (Paper No. 59—A-19)

Coupled Torsional and Longitudinal Vibrations of a Thin-Bar, by *R. C. DiPrima*, Rensselaer Polytechnic Inst. (Paper No. 59—A-18)

Dominance of Shear Stresses in Early Stages of Impulsive Motion of Beams, by *H. H. Bleich*, Columbia Univ., and *R. P. Shaw*, Pratt Inst. (Paper No. 59—A-60)

Impact and Moving Loads on a Slightly Curved Elastic Half Space, by *A. C. Eringen* and *J. C. Samuels,* Purdue Univ. (Paper No. 59—A-2)

Forced Vibrations of a Circular Plate, by *Herbert Reismann,* The Martin Co. (Paper No. 59—A-9)

IX THURSDAY, DECEMBER 3 2:30 p.m.

Mechanisms

An Analytical Method for Locating the Burmester Points for Five Infinitesimally Separated Positions of the Coupler Plane of a Four-Bar Mechanism,[2] by *J. C. Wolford,* Univ. of Nebraska (Paper No. 59—A-11)

Approximate Synthesis of Spatial Linkages, by *Jacques Denavit* and *R. S. Hartenberg,* Northwestern Univ. (Paper No. 59—A-24)

On the Annular Damper for a Freely Precessing Gyroscope, by *G. F. Carrier,* Harvard Univ., and *J. W. Miles,* Univ. of California (Paper No. 59—A-44)

A Unified Criterion for the Degree of Constraint of Plane Kinematic Chains, by *B. Paul,* Brown Univ. (Paper No. 59—A-34)

A Perturbation Solution of the Equations of Motion of a Gyroscope,[2] by *Robert Goodstein,* Boeing Airplane Co. (Paper No. 59—A-5)

Elastic Flexible Cable in Plane Motion Under Tension, by *Wen-Hsiung Li,* Syracuse Univ. (Paper No. 59—A-6)

The Motion and Loading of a Hinged Ramp Which Supports a Sliding Mass,[2] by *B. Saelman,* Lockheed Aircraft Corp. (Paper No. 59—A-85)

X FRIDAY, DECEMBER 4 9:30 a.m.

Jointly with Lubrication

See Lubrication II

AVIATION SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Missile and Satellite Ground-Radar Structure and Drive Development

Design of the FPS-35 Antenna,[1] by *C. W. Souder,* Sperry Gyroscope Co.

Rotative Power for Large Antennas,[1] by *D. A. Regillo* and *P. A. Crosby,* M.I.T., Lincoln Lab.

Criteria for Design of Foundations for Precision-Tracking Radars Considering Dynamic Response,[1] by *Chen Fu* and *J. W. Jepson,* Bell Telephone Labs.

Millstone-Type Radar Antenna Systems,[1] by *J. F. Hutzenlaub, L. A. Baghdoyan,* and *A. O. Kuhnel,* M.I.T., Lincoln Lab.

II MONDAY, NOVEMBER 30 2:30 p.m.

Ground-Radar Structure and Drive Development

Mechanical Design of a 150-Ft Diam Metal Space-Frame Radome,[1] by *L. P. Farnsworth* and *T. F. King,* M.I.T., Lincoln Lab.

High-Response Hydraulic Servo Transmission for Target-Tracking Radar Drive,[1] by *T. E. Beal,* Vickers, Inc.

Criteria for the Electromechanical Design of Feed Systems and R. F. Components in Large High Power UHF Radars,[1] by *E. W. Blaisdell, M. W. Brawn,* and *A. M. Sanderson,* M.I.T., Lincoln Lab.

III TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Maintenance

Jet Transport Maintenance

Turbine-Propeller Power-Plant Airline Maintenance, by *D. W. Crosby,* Eastern Airlines, Inc. (Paper No. 59—A-189)

Development of a Maintenance Program for Jet Transport Aircraft, by *J. F. Roche,* Trans World Airlines, Inc. (Paper No. 59—A-187)

Overhaul-Shop Planning for the P&WA Jets, by *E. C. Norton,* Pratt & Whitney Aircraft (Paper No. 59—A-229)

IV TUESDAY, DECEMBER 1 2:30 p.m.

Reliability of Weapons Systems

Government and Industry Attack the Reliability Problem,[1] by *F. A. Thompson,* Bureau of Aeronautics, Dept. of the Navy

[1] Paper available at Meeting.

Unique Aspects of the F4H Airplane Reliability Effort,[1] by *G. A. Kunsnick,* McDonnell Aircraft Corp.

Distribution of Service Lives of Hydraulic Pumps,[1] by *J. de S. Coutinho,* Grumman Aircraft Engrg. Corp.; Polytechnic Inst. of Brooklyn

V TUESDAY, DECEMBER 1 8:00 p.m.

Jointly with Gas Turbine Power

Reliability of Gas Turbines

Gas-Turbine Reliability Procurement Procedures, by *R. R. Brown,* Bureau of Aeronautics, Dept. of the Navy (Paper No. 59—A-219)

Developing Reliability in the T58 Engine Control,[1] by *R. H. Rosenberg,* Gen. Elec. Co.

Jet Engine Trend Analysis,[1] by *P. J. Bruneau,* Bureau of Aeronautics, Navy Dept.

VI WEDNESDAY, DECEMBER 2 9:30 a.m.

Aircraft and Missile Structure

Optimum Tolerances of Sheet Materials for Flight Vehicles, by *G. A. Hoffman,* The RAND Corp. (Paper No. 59—A-70)

A Note of the Calculation of the Strength of Specimens Containing Fatigue Cracks, by *A. J. McEvily, Jr., Walter Illg,* and *H. F. Hardrath,* NASA, Langley Research Center (Paper No. 59—A-235)

Structural Weight Approximation for a Bell-Nozzle Divergent Section, by *G. D. Brewer,* Grand Central Rocket Co., and *E. Levin,* The RAND Corp. (Paper No. 59—A-69)

Improved Air-Induction System Through the Use of Interaction,[1] by *M. L. Morris,* Curtiss-Wright Corp.

VII WEDNESDAY, DECEMBER 2 2:30 p.m.

Wind Tunnel

Elimination of Noise in the Heat Exchanger of a Supersonic Wind Tunnel, by *R. R. Godman* and *Samuel Stein,* NASA (Paper No. 59—A-232)

A High-Temperature-Pressure Air Heater (Suitable for Intermittent Hypersonic Wind-Tunnel Operation), by *M. H. Bloom,* Polytechnic Inst. of Brooklyn (Paper No. 59—A-233)

Supersonic Wind-Tunnel Air-Drying System Design, by *T. W. Macios,* Sverdrup & Parcel Engrg. Co. (Paper No. 59—A-161)

BOILER FEEDWATER STUDIES SESSIONS

I WEDNESDAY, DECEMBER 2 9:30 a.m.

Annual Report of the Joint Research Committee on Boiler-Feedwater Studies (Not to be printed), by *M. D. Baker,* West Penn Power Co.

Gaps in Our Knowledge of Steam Sampling,[1] by *Henry Phillips,* Foster Wheeler Corp.

Results of Steam-Sampling-Nozzle Tests on Evaporator Vapor,[1] by *T. A. Miskimen,* American Elec. Power Service Corp

II WEDNESDAY, DECEMBER 2 2:30 p.m.

Panel: Corrosion in High-Pressure Boilers

Theories of Corrosion in High-Pressure Boilers, (Not to be printed), by *D. E. Noll,* Hagan Chemicals & Controls, Inc.

Relation of Plant and Boiler Design to Corrosion in High-Pressure Boilers (Not to be printed), by *E. A. Pirsh,* The Babcock & Wilcox Co.

Relation of Plant and Boiler Operation to Corrosion in High-Pressure Boilers (Not to be printed), by *J. D. Ristroph,* Virginia Elec. & Power Co.

Relation of Plant and Boiler-Water Chemistry to Corrosion in High-Pressure Boilers (Not to be printed), by *H. A. Grabowski,* Combustion Engrg. Inc.

A Metallurgical Look Into the Future (Not to be printed), by *J. W. Freeman,* Univ. of Michigan

CORROSION AND DEPOSITS SESSION

I FRIDAY, DECEMBER 4 9:30 a.m.

Jointly with Fuels

An Experimental Investigation of Fuel Additives in a Supercharged Boiler, by *R. J. Zoschak* and *R. W. Bryers,* Foster Wheeler Corp. (Paper No. 59—A-160)

Corrosion of Superheaters and Reheaters of Pulverized-Coal Fired Boilers, by *Wharton Nelson* and *Carl Cain, Jr.,* Combustion Engrg., Inc. (Paper No. 59—A-89)

External Corrosion of Superheaters in Boilers Firing High-Alkali Coals, by *P. Sedor, E. K. Diehl,* and *D. H. Barnhart,* The Babcock & Wilcox Co. (Paper No. 59—A-76)

EFFECT OF TEMPERATURE SESSIONS

TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Metals Engineering

See Metals Engineering III

TUESDAY, DECEMBER 1 2:30 p.m.

Jointly with Metals Engineering

See Metals Engineering IV

FLUID METERS SESSIONS

TUESDAY, DECEMBER 1 8:00 p.m.

Jointly with Power Test Codes

See Power Test Codes

I THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Instruments and Regulators, and Petroleum

Small Flow Measurement

The Quadrant Edge Orifice—A Fluid Meter for Low Reynolds Numbers, by *Marvin Bogema* and *P. L. Monkmeyer,* Cornell Univ. (Paper No. 59—A-140)

Coefficients of Discharge of a Quadrant-Type Concentric Orifice Meter, With Flange, Radius, and Corner Taps, by *Hector Lopez-Ramos* and *Carlos Duhne,* Monterrey Inst. of Tech., Monterrey, N. L. Mexico; *Norberto Valverde,* Viscose de Chihuahua, Chihuahua, Chih., Mexico; *Santiago F. Mireles-del Campo,* Saltillo, Coah., Mexico; and *L. P. Emerson,* The Foxboro Co. (Paper No. 59—A-106)

Small Diameter Orifice Metering, by *T. J. Filban* and *W. A. Griffin,* Daniel Orifice Fitting Co. (Paper No. 59—A-101)

II THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Instruments and Regulators, and Petroleum

New Type Flow Meters

The Twin Throat Venturi: A New Fluid-Flow Measuring Device, by *A. A. Kalinske,* INFILCO Inc. (Paper No. 59—A-154)

A Study of Viscosity Effect and Its Compensation on Turbine-Type Flowmeters, by *W. F. Z. Lee* and *Henning Karlby,* Rockwell Mfg. Co. (Paper No. 59—A-105)

FUELS SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Application of Model Studies to Industrial Gas-Flow Systems,[1] by *C. L. Burton* and *R. E. Willison,* Research-Cottrell, Inc.

A Superior Collecting Plate for Electrostatic Precipitators,[1] by *H. J. White* and *W. A. Baxter, Jr.,* Research-Cottrell, Inc.

Pressurization of Granular Solid Fuels, by *M. N. Aref,* Foster Wheeler Corp. (Paper No. 59—A-150)

II MONDAY, NOVEMBER 30 2:30 p.m.

Oil-Ash Corrosion of Superheater Alloys in a Pilot-Scale Furnace—Reduction by Use of Addi-

Registration Schedule

Sunday, November 29	2:00 p.m. to 5:00 p.m.
Monday, November 30	8:00 a.m. to 3:00 p.m.
Tuesday, December 1	8:00 a.m. to 8:00 p.m.
Wednesday, December 2	8:00 a.m. to 8:00 p.m.
Thursday, December 3	8:00 a.m. to 3:00 p.m.
Friday, December 4	8:00 a.m. to 10:00 a.m.

tives,[1] by *N. D. Phillips* and *C. L. Wagoner*, The Babcock & Wilcox Co.

The Direct Method of Testing Heating and Power Boilers,[1] by *E. P. Carman*, Fuels Consulting & Testing Associates

Heat-Balance Efficiency by Approximation,[1] by *C. R. Mueller*, Hoffman Combustion Engrg. Co.

III TUESDAY, DECEMBER 1 9:30 a.m.

American Coal Characteristics and Their Effects on Design of Steam-Generating Units, by *A. F. Dusy*, The Babcock & Wilcox Co. (Paper No. 59—A-242)

The Combustion of European Coals in Modern German Steam Generators,[1] by *Georg Redottée*, *Hermann Hennecke*, and *Paul Pracht*, Deutsche Babcock & Wilcox-Dampfkessel-Werke AG., Oberhausen-Rheinland, Western Germany (Paper No. 59—A-194)

IV TUESDAY, DECEMBER 1 2:30 p.m.

Boiler-Furnace Explosion Survey,[1] by *J. B. Smith*, Factory Mutual Engrg. Div.

Protecting Industrial Furnaces From Explosions,[1] by *M. L. Jones*, E. I. du Pont de Nemours & Co., Inc.

Five Years' Experience With Remote Burner Systems,[1] by *M. L. Crull* and *A. B. Dunn*, Dept. of Water & Power, Los Angeles, Calif.

FRIDAY, DECEMBER 4 9:30 a.m.

Jointly with Corrosion and Deposits

See Corrosion and Deposits

GAS TURBINE POWER SESSIONS

TUESDAY, DECEMBER 1 8:00 p.m.

Jointly with Aviation

See Aviation V

I WEDNESDAY, DECEMBER 2 9:30 a.m.

The Radial Turbine, for Low Specific Speeds and Low Velocity Factors,[1] by *E. M. Knoernschild*, The Garrett Corp.

Design and Development of a Convective Air-Cooled Turbine and Test Facility,[1] by *W. F. Weatherwax*, Gen. Elec. Co.

Practical Solution of Calculating Natural Frequencies of Rotating and Nonrotating Twisted Cantilevered Beams,[1] by *B. Jaeger*, Daimler-Benz, Stuttgart, Germany, and *Paul Hermann*, Fairchild Engine & Airplane Corp.

II WEDNESDAY, DECEMBER 2 2:30 p.m.

Some Considerations for the Reduction of Noise From Ship Installations of Gas Turbines, by *E. M. Herrmann*, U. S. Naval Engrg. Experiment Station (Paper No. 59—A-238)

25,000-KW Mene Grande Gas-Turbine Installations, by *C. M. Honaker*, Mene Grande Oil Co., Barcelona, Venezuela, and *D. F. Bruce*, Westinghouse Elec. Corp. (Paper No. 59—A-191)

III WEDNESDAY, DECEMBER 2 8:00 p.m.

Symposium: Gas-Turbine Experience at Sea

Development and Sea Trials of Marine Proteus Engines for Brave-Class Fast Patrol Boats,[1] by *B. G. Markham*, Bristol Siddeley Engines Ltd., Bristol, England

Marine and Mobile Applications of Industrial Gas Turbines,[1] by *E. O. Kohn*, Ruston & Hornsby, Ltd, Lincoln, England

IV THURSDAY, DECEMBER 3 9:30 a.m.

Gas-Turbine Propulsion for Hydrofoil Craft,[1] by *K. A. Austin*, Avco Corp.

Development of a 3500-HP Marine-Gas Turbine, by *D. W. Knowles*, Curtiss-Wright Corp. (Paper No. 59—A-199)

The Combined Steam-Turbine Gas-Turbine Plant for Marine Use, by *R. G. Mills*, Bur. of Ships, Navy Dept. (Paper No. 59—A-237)

HEAT TRANSFER SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Heat Transfer to Freon 12 Near the Critical State in a Natural Circulation Loop, by *J. P. Holman*, Aeronautical Research Lab., WADC, and *J. H. Boggs*, Oklahoma State Univ. (Paper No. 59—A-142)

Experiments on Heat Transfer From Spheres Including Combined Natural and Forced Convection, by *T. Yuge*, Tohoku Univ., Sendai, Japan (Paper No. 59—A-123)

Combined Free and Forced-Convection Heat-Generating Laminar Flow Inside Vertical Pipes With Circular Sector Cross Sections, by *Pau-Chang Lu*, Case Inst. of Tech. (Paper No. 59—A-145)

On Combined Free and Forced Convection in Channels, by *L. N. Tao*, Illinois Inst. of Tech. (Paper No. 59—A-77)

Thermal Contact Resistance in Finned Tubing, by *K. Gardner*, Yuba Consolidated Industries, Inc., and *T. C. Carnavos*, The Griscom-Russell Co. (Paper No. 59—A-135)

II MONDAY, NOVEMBER 30 2:30 p.m.

Transient Temperatures and Thermal Stresses in Hollow Cylinders Due to Heat Generation, by *J. E. Schmidt* and *George Sonnemann*, Univ. of Pittsburgh (Paper No. 59—A-144)

The Effect of Apparent Density and Gas-Cell Size on the Thermal Conductivity of Cellular Materials, by *M. E. Stephenson, Jr.*, Raytheon Co. and *Melvin Mark*, Lowell Technological Inst. (Paper No. 59—A-254)

The Apparent Thermal Conductivity of Fibrous Materials,[1] by *J. J. Thigpen*, Louisiana Polytechnic Inst., and *B. E. Short*, The Univ. of Texas

III TUESDAY, DECEMBER 1 9:30 a.m.

Mass Transfer, Flow, and Heat Transfer About a Rotating Disk, by *E. M. Sparrow* and *J. L. Gregg*, NASA, Lewis Research Center (Paper No. 59—A-107)

Heat Transfer and Effectiveness for a Turbulent Boundary Layer With Tangential Fluid Injection, by *R. A. Seban*, Univ. of California (Paper No. 59—A-177)

Sublimation Mass Transfer Through Compressible Boundary Layers on a Flat Plate, by *T. K. Sherwood*, M.I.T., and *Olev Trass*, Univ. of Toronto, Toronto, Ont., Canada (Paper No. 59—A-137)

Laminar Skin Friction and Heat Transfer on Flat Plates With Wedge-Shaped Grooves in Flow Direction, by *T. F. Irvine, Jr.*, and *E. R. G. Eckert*, Univ. of Minnesota (Paper No. 59—A-143)

IV TUESDAY, DECEMBER 1 2:30 p.m.

Heat Transfer to Liquid Metals With Variable Properties, by *Raymond Viskanta*, Argonne Nat. Lab., and *Y. S. Touloukian*, Purdue Univ. (Paper No. 59—A-148)

Remarks on the Temperature-Step Functions on a Flat Plate in Forced Convection, by *H. H. Sogin*, Brown Univ. (Paper No. 59—A-188)

A Summary of Experiments on Turbulent Heat Transfer From a Nonisothermal Flat Plate, by *W. C. Reynolds*, *W. M. Kays*, and *S. J. Kline*, Stanford Univ. (Paper No. 59—A-157)

An Experimental Study of the Effects of Nonuniform Wall Temperature on Heat Transfer in Laminar and Turbulent Axisymmetric Flow Along a Cylinder by *R. Eichhorn*, Princeton Univ., *E. R. G. Eckert* and *A. D. Anderson*, Univ. of Minnesota (Paper No. 59—A-151)

V WEDNESDAY, DEC. 2 9:30 a.m.

Sensory Reception and the Control of Temperature in Man, by *T. H. Benzinger*, Naval Medical Research Inst. (Paper No. 59—A-214)

Heat Stress and the Industrial Worker,[1] by *Lucien Brouha*, *P. E. Smith, Jr.*, and *Mary E. Maxfield*, E. I. du Pont de Nemours & Co., Inc. (Paper No. 59—A-213)

Exposure to Aerodynamic Heating Transients, by *Paul Webb*, consultant, Yellow Springs, Ohio (Paper No. 59—A-211)

The Effect of Temperature on Tolerance to Positive Acceleration, by *B. F. Burgess, Jr.*, U. S. Naval Air Development Center (Paper No. 59—A-212)

VI-A WEDNESDAY, DEC. 2 2:30 p.m.

Panel Discussion: The Undergraduate Teaching of Heat Transfer

Frank Kreith, Univ. of Colorado

A. C. Mueller, E. I. du Pont de Nemours & Co. Inc.

K. G. Picha, Nat. Science Foundation

W. M. Rohsenow, M.I.T.

VI-B WEDNESDAY, DEC. 2 2:30 p.m.

The Role of Skin in Heat Transfer, by *Alice M. Stoll*, U. S. Naval Air Development Center (Paper No. 59—A-138)

The Effective Stimulus for Warmth Sensation in Man, by *Edwin Hendler*, Naval Air Material Center, and *J. D. Hardy*, The Univ. of Pennsylvania (Paper No. 59—A-208)

Heat Stress in a Desert Environment, by *Austin Henschel* and *H. E. Hanson*, Quartermaster Research & Engrg. Command (Paper No. 59—A-210)

Prediction of Heat-Stressed Skin-Boundary Temperatures: Partial Rates of Change Associated With (*a*) Operative Temperature and Vapor Pressure, (*b*) With Operative Temperature, Metabolism, and Evaporation, by *L. P. Herrington*, John B. Pierce Foundation (Paper No. 59—A-209)

VII THURSDAY, DEC. 3 9:30 a.m.

A Theoretical Analysis of a Peltier Refrigerator,[1] by *E. B. Penrod*, Univ. of Kentucky

Climatic Considerations in the Design of Air-Cooled Heat Exchangers, by *G. F. Collins*, Lockheed Aircraft Corp., and *R. T. Mathews*, E. I. du Pont de Nemours & Co., Inc. (Paper No. 59—A-255)

Thermal Comfort in Space Vehicles, by *J. E. Janssen*, Honeywell Research Center (Paper No. 59—A-207)

The Prediction of Human Tolerance When Using a Ventilating Garment With an Anti-Exposure Suit, by *J. W. McCutchan*, Univ. of California (Paper No. 59—A-114)

VIII THURSDAY, DEC. 3 2:30 p.m.

Certain Thermodynamic Properties of the Atmospheres of Venus, Mars, and Jupiter, by *T. F. Irvine, Jr.*, and *W. E. Ibele*, Univ. of Minnesota (Paper No. 59—A-102)

Application of Variational Methods to Radiation Heat-Transfer Calculations, by *E. M. Sparrow*, NASA, Lewis Research Center (Paper No. 59—A-120)

Geometric Factors for Radiative Heat Transfer Through Absorbing Medium in Cartesian Coordinates, by *A. K. Oppenheim* and *J. T. Bevans*, Shell Development Co. (Paper No. 59—A-206)

[1] Paper available at Meeting.

Thermal Radiation From a Cylindrical Enclosure With Specified Wall Heat Flux, by *C. M. Usiskin* and *R. Siegel*, NASA, Lewis Research Center (Paper No. 59—A-159)

IX FRIDAY, DECEMBER 4 9:30 a.m.

Heat-Transfer Performance of Condenser Tubes, by *J. A. Stawicki* and *J. S. Ungar*, Consolidated Edison Co. of New York, Inc. (Paper No. 59—A-225)

Local and Average Heat-Transfer and Pressure-Drop for Refrigerants Evaporating in Horizontal Tubes,[1] by *M. Altman, R. H. Norris,* and *F. W. Staub*, Gen. Elec. Co.

A Systematic Approach to the Design of Compact Heat Exchangers, by *W. B. Hendry*, Westinghouse Elec. Corp. (Paper No. 59—A-193)

Heat-Transfer and Flow-Friction Characteristics of Crossed-Rod Matrices, by *A. L. London* and *J. W. Mitchell*, Stanford Univ., and *W. A. Sutherland*, Gen. Elec. Co. (Paper No. 59—A-168)

FRIDAY, DECEMBER 4 9:30 a.m.

Jointly with Solar Energy

See Solar Energy

HUMAN FACTORS SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Jointly with Management and Human Factors Society

Improving Man's Workload in Space-Vehicle Systems: Methodology and Measurement, by *A. J. Latham*, Chance Vought Aircraft, Inc. (Paper No. 59—A-195)

Man's Response to Low-Frequency Vibration, by *M. A. Schmitz* and *A. K. Simons*, Bostrom Research Labs. (Paper No. 59—A-200)

How Common Is Common Sense, by *P. L. Flatow*, New York Univ., and *Mrs. Gene Weeks*, Gene Weeks & Associates (Paper No. 59—A-258)

II MONDAY, NOVEMBER 30 2:30 p.m.

Jointly with Management and Human Factors Society

Manpower, by *E. S. Krendel*, The Franklin Inst. (Paper No. 59—A-190)

Some Human Factors Considerations in the Development of Upper Extremity Prostheses, by *Anthony Staros*, Veterans Administration Prosthetics Center (Paper No. 59—A-184)

Duplication of Human Hand Function, by *M. J. Fletcher*, Walter Reed Army Medical Center (Paper No. 59—A-262)

TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Instruments and Regulators

See Instruments and Regulators II

HYDRAULIC SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Fluid Power Systems

Relief Valves foı Mobile Applications,[1] by *C. A. L. Ruhl*, The New York Air Brake Co.

Calculating Effective Thrust Loads in Axial Piston Pumps,[1] by *N. M. Wickstrand*, The Torrington Co.

II MONDAY, NOVEMBER 30 2:30 p.m.

Water Hammer

Charts for Determining Size of Surge Suppressors for Pump-Discharge Lines, by *C. W. Lundgren*, Bureau of Reclamation, U. S. Dept. of Interior (Paper No. 59—A-73)

Surge-Tank Stability and the Validity of the Formula of Thoma,[1] by *Charles Jaeger*, English Elec. Co. Ltd., London, England

Viscous Dispersion in Water Hammer, by *M. L. Walker, Jr.*, Carnegie Inst. of Tech., *E. T. Kirkpatrick*, Univ. of Toledo, and *W. T. Rouleau*, Carnegie Inst. of Tech. (Paper No. 59—A-12)

[1] Paper available at Meeting.

III TUESDAY, DECEMBER 1 9:30 a.m.

Hydraulic Prime Movers—1

Vibration of Water-Turbine Draft Tubes,[2] by *Mitsukiyo Murakami*, Osaka City Univ., Osaka, Japan (Paper No. 59—A-96)

Reversible Pump Turbines at Niagara Falls, by *F. E. Jaski* and *W. W. Wellmer*, Allis-Chalmers Mfg. Co. (Paper No. 59—A-87)

A New Runaway Speed Limiter for Kaplan Turbines, by *G. H. Voaden*, Allis-Chalmers Mfg. Co. (Paper No. 59—A-103)

IV TUESDAY, DECEMBER 1 2:30 p.m.

Hydraulic Prime Movers—2

Simplified Instrumentation and Field Checking of Hydraulic-Turbine Governors, by *B. E. Wheeler*, Baldwin-Lima-Hamilton Corp. (Paper No. 59—A-124)

Field Testing and Adjusting of Hydraulic-Turbine Governors to Improve System Regulation, by *H. M. Stone*, Southern California Edison Co. (Paper No. 59—A-149)

Field Adjustment of Hydraulic-Turbine Governors, by *C. L. Avery*, Woodward Governor Co. (Paper No. 59—A-108)

V-A WEDNESDAY, DEC. 2 9:30 a.m.

Fluid Mechanics—1

Flow Phenomena of Partially Enclosed Rotating Disks, by *L. A. Maroti*, Ingersoll-Rand Co., *G. I. Deak*, M.I.T., and *Frank Kreith*, Univ. of Colorado (Paper No. 59—A-49)

Roughness Effects on Frictional Resistance of Enclosed Rotating Disks, by *R. E. Nece*, Univ. of Washington, and *J. W. Daily*, M.I.T. (Paper No. 59—A-55)

Radial Distributions of Temporal-Mean Peripheral Velocity and Pressure for Fully Developed Turbulent Flow in Curved Channels, by *A. W. Marris*, Univ. of British Columbia, Vancouver, B.C., Canada (Paper No. 59—A-51)

V-B WEDNESDAY, DEC. 2 9:30 a.m.

Compressors

A Torsional Vibration Problem as Associated With Synchronous Motor-Driven Machines, by *R. N. Brown*, Allis-Chalmers Mfg. Co. (Paper No. 59—A-141)

A Small Free-Piston Engine-Compressor, by *J. H. McNinch, W. W. Vogelhuber,* and *R. J. McCrory*, Battelle Memorial Inst. (Paper No. 59—A-97)

Design Control of Overcompression in Rotary-Vane Compressors, by *E. O. Bransford*, Beaman Engrg. Co., and *R. A. Stein*, Battelle Memorial Inst. (Paper No. 59—A-109)

VI-A WEDNESDAY, DEC. 2 2:30 p.m.

Fluid Mechanics—2—Compressors

A Study of Boundary-Layer Characteristics of Turbomachine-Blade Rows and Their Relation to Over-All Blade Loss, by *W. L. Stewart, W. J. Whitney,* and *R. Y. Wong*, NASA, Lewis Research Center (Paper No. 59—A-23)

Rotating Wakes in Vaneless Diffusers, by *R. C. Dean, Jr.*, Ingersoll-Rand Co., and *Yasutoshi Senoo*, M.I.T. (Paper No. 59—A-104)

Incidence and Deviation Angle Correlations for Compressor Cascades, by *Seymour Lieblein*, NASA, Lewis Research Center (Paper No. 59—A-171)

VI-B WEDNESDAY, DEC. 2 2:30 p.m.

Cavitation and Pumping Machinery—Part 1

Selection of Length and Head Scales for Cavitation Tests,[2] by *Pierre Danel* and *Jacques Duport*, Sogreah, Grenoble, France (Paper No. 59—A-40)

Some Corrosion Effects in Accelerated Cavitation Damage, by *W. C. Leith*, Dominion Engrg. Works, Montreal, Que., Canada, and *A. L. Thompson*, McGill Univ., Montreal, Que., Canada (Paper No. 59—A-52)

On Cathodic Protection in Cavitation Damage, by *M. S. Plesset*, California Inst. of Tech. (Paper No. 59—A-170)

[2] Not presented orally.

Correlation of Cavitation-Inception Data for a Centrifugal Pump Operating in Water and in Sodium-Potassium Alloy (NaK), by *A. G. Grindell*, Oak Ridge Nat. Lab. (Paper No. 59—A-156)

VII WEDNESDAY, DEC. 2 8:00 p.m.

Cavitation and Pumping Machinery—Part 2

Design of Suction Piping and Deaerator Storage Capacity to Protect Feed Pumps, by *R. S. Thurston*, Los Alamos Scientific Lab. (Paper No. 59—A-20)

Centrifugal Pumps Used as Hydraulic Turbines, by *C. P. Kittredge*, Princeton Univ. (Paper No. 59—A-136)

Cavitation in Centrifugal Pumps With Liquids Other Than Wate., by *A. J. Stepanoff*, Ingersoll-Rand Co. (Paper No. 59—A-158)

VIII-A THURSDAY, DEC. 3 9:30 a.m.

Fluid Mechanics—3

The Turbulent Boundary Layer at a Plane of Symmetry in a Three-Dimensional Flow, by *J. P. Johnston*, Ingersoll-Rand Co. (Paper No. 59—A-72)

Laminar Boundary Layers in Oscillatory Flow,[1] by *P. G. Hill* and *A. H. Stenning*, M.I.T.

Experimental Determination of Statistical Properties of Two-Phase Turbulent Motion, by *S. L. Soo* and *H. K. Ihrig, Jr.*, Univ. of Illinois, and *A. F. El Kouh*, Princeton Univ. (Paper No. 59—A-59)

VIII-B THURSDAY, DEC. 3 9:30 a.m.

Consultants and Contractors Symposium on Centrifugal Compressors

Application of Centrifugal Compressors to Aerodynamic Testing (Not to be printed), by *S. L. Elmer, Jr.*, Sverdrup & Parcel Engrg. Co.

Application of Centrifugal Compressors in Vacuum-Pump Service (Not to be printed), by *R. N. Hancock*, Foster Wheeler Corp.

Review of Some Problems Encountered in the Application and Operation of Centrifugal Compressors (Not to be printed), *Hays Mayo*, The M. W. Kellogg Co.

Selection of Centrifugal Compressor Drives, (Not to be printed), by *F. L. Gillett*, C. F. Braun & Co.

Problems Involved in the Selection of Centrifugal Compressors (Not to be printed), by *C. E. Freese*, The Fluor Corp., Ltd.

IX THURSDAY, DECEMBER 3 2:30 p.m.

Fluid Mechanics—4

Heat-Transfer Characteristics of a Hot-Film Sensing Element Used in Flow Measurement, by *S. C. Ling*, Underwood Corp. (Paper No. 59—A-172)

Variable Flow Resistance With Adjustable Multihole Orifice Plates in Series, by *J. Sherman, F. A. Grochowski,* and *J. E. Sharbaugh*, Westinghouse Elec. Corp. (Paper No. 59—A-182)

The Adiabatic Bulk Modulus of Normal Paraffin Hydrocarbons From Hexane to Hexadecane, by *R. E. Rolling* and *C. J. Vogt*, Univ. of California (Paper No. 59—A-169)

Influence of Orifice Geometry on Static Pressure Measurements,[2] by *R. E. Rayle*, U. S. Army Ordnance Dept. (Paper No. 59—A-234)

INSTRUMENTS AND REGULATORS SESSIONS

MONDAY, NOVEMBER 30 9:30 a.m.

Jointly with Mechanical Pressure Elements

See Mechanical Pressure Elements

I MONDAY, NOVEMBER 30 2:30 p.m.

Requirements for a Hybrid Analog-Digital Computer,[1] by *J. H. Milsum* and *D. C. Baxter*, Nat. Research Council of Canada, Ottawa, Ont., Canada

Experimental Verification of a Design Basis for Positional Servomechanisms, by *Sidney Lees*, United Research, Inc., *T. C. Blaschke*, M.I.T.

B. B. Brown, and *C. J. Ostertag, Jr.*, U. S. Navy (Paper No. 59—A-239)

A Performance Criterion for Operating Systems,[1] by *D. W. Batteau*, Harvard Univ.

Encoding Spatial Angle Measurements by Optical Means Employing Digital Cameras,[1] by *John Ward*, M.I.T.

II TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Human Factors

Dynamics of Heat Exchangers and Their Models, by *Herman Thal-Larsen*, Univ. of California (Paper No. 59—A-117)

Application of a Portable Spectroscope to the Rapid Identification of Alloy Steels, by *D. R. Stoss* and *P. E. Sherman*, Gen. Elec. Co. (Paper No. 59—A-56)

A Multipoint Electronic Manometer System for Low-Pressure Hypersonic Wind Tunnels, by *P. L. Vitkus*, NRC Equipment Corp. (Paper No. 59—A-217)

Precise Measurement of Clothes Insulation During Controlled Operation of the Human, by *A. S. Iberall*, Rand Development Corp. (Paper No. 59—A-197)

Control-Valve Terminology,[1,2] by Terminology Committee, ASME-IRD

THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Fluid Meters and Petroleum

See Fluid Meters I

THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Fluid Meters and Petroleum

See Fluid Meters II

JUNIOR SESSION

TUESDAY, DECEMBER 1 8:00 p.m.

Panel Discussion

How to Double Your Income—From the Point of View of a Consulting Engineer (Not to be printed), by *W. R. Thompson*, United Engrs. & Constructors, Inc.

How to Double Your Income—From the Point of View of a Sales Engineer (Not to be printed), by *F. R. Danker*, American Standard

How to Double Your Income—From the Point of View of a Design Engineer (Not to be printed), by *V. P. Buscemi*, Westinghouse Elec. Corp.

LUBRICATION SESSIONS

I THURSDAY, DECEMBER 3 2:30 p.m.

Review of Symposium on Gas-Lubricated Bearings (Not to be printed), by *D. D. Fuller*, Columbia Univ.

Progress Report on Recommended Practices for the Design of Marine-Propulsion Turbine Lubricating Systems,[1] by *A. S. Morrow*, Shell Oil Co.

II FRIDAY, DECEMBER 4 9:30 a.m.

Jointly with Applied Mechanics

A Theory of Lubrication With Turbulent Flow and Its Application to Slider Bearings, by *L. N. Tao*, Illinois Inst. of Tech. (Paper No. 59—A-26)

Theoretical and Experimental Analysis of Hydrostatic Thrust Bearings, by *B. Sternlicht* and *R. C. Elwell*, Gen. Elec. Co. (Paper No. 59—A-152)

MACHINE DESIGN SESSIONS

I TUESDAY, DECEMBER 1 2:30 p.m.

Turbine-Bearing Design, by *P. C. Warner*, Westinghouse Elec. Corp. (Paper No. 59—A-127)

[1] Paper available at Meeting.
[2] Not presented orally.

Determination of Cutter Trajectories for Contoured Turbine Buckets, by *R. G. DeBiase*, Gen. Elec. Co. (Paper No. 59—A-111)

Automatic Milling of Steam-Turbine Buckets, by *R. H. Wilke* and *Don Rubio*, Gen. Elec. Co. (Paper No. 59—A-98)

II WEDNESDAY, DECEMBER 2 9:30 a.m.

Synthesis of Epicyclic Gear Trains Using the Velocity Ratio Spectrum, by *R. C. Brewer*, Univ. of London, South Kensington, London, England (Paper No. 59—A-22)

Gear Position Error Control—Limitation of Total Composite Error in Controlling Position Error of Gears, by *G. W. Michalec*, Gen. Precision Lab., Inc. (Paper No. 59—A-21)

Helixform Bevel and Hypoid Gears, by *C. B. King, G. M. Spear*, and *M. L. Baxter, Jr.*, Gleason Works (Paper No. 59—A-90)

The Twinworm Drive—A Self-Locking Worm-Gear Transmission of High Efficiency,[4] by *B. Popper*, Israel Ministry of Defense, Tel Aviv, Israel, and *D. W. Pessen*, Israel Inst. of Tech., Haifa, Israel (Paper No. 59—A-75)

III WEDNESDAY, DEC. 2 2:30 p.m.

Strength of Helical Gear Teeth, by *E. J. Wellauer*, The Falk Corp. (Paper No. 59—A-121)

Bending Strength of Gear Teeth by Cantilever Plate Theory, by *E. J. Wellauer* and *Ali Seireg*, The Falk Corp. (Paper No. 59—A-50)

Rocket Motor Gear-Tooth Analysis (Hertzian Contact Stresses and Times), by *R. W. Prowell* and *E. K. Gatcombe*, U. S. Naval Postgraduate School (Paper No. 59—A-256)

IV WEDNESDAY, DEC. 2 8:00 p.m

Mechanical Vibration Filters With Nonlinear Characteristics, by *W. J. Worley*, Univ. of Illinois (Paper 59—A-42)

Refinement of Finite Difference Calculations in Kinematic Analysis, by *B. W. Shaffer* and *Irvin Krause*, New York Univ. (Paper No. 59—A-53)

The Measurement of Very Low Frictional Torques in Rotating Equipment,[2] by *Melvin Zaid*, technical consultant, Plainview, N. Y., and *I. S. Tolins*, Ford Instrument Co. (Paper No. 59—A-43)

Design by Quantitative Factor of Safety,[4] by *H. L. Su*, London, England (Paper No. 59—A-48)

Study of Critical Velocity of Stick-Slip Sliding,[4] by *B. R. Singh*, Britannia Engrg. Co., Ltd., West Bengal, India (Paper No. 59—A-146)

V THURSDAY, DECEMBER 3 9:30 a.m.

Dimensionless Parameters for Helical Compression Springs, by *R. J. Erisman*, Intl. Harvester Co. (Paper No. 59—A-30)

Positive-Acceleration Clutch, by *R. C. Ebersold*, The Warner & Swasey Co. (Paper No. 59—A-54)

Deformations and Moments in Elastically Restrained Circular Plates Under Arbitrary Load or Linear Thermal Gradient, by *Melvin Zaid* and *Marvin Forray*, Republic Aviation Corp. (Paper No. 59—A-39)

VI THURSDAY, DECEMBER 3 2:30 p.m.

Inertial Effects in a Multiple-Ball Transmission, by *W. S. Rouverol*, Univ. of California (Paper No. 59—A-14)

Some Applications of the Cycloid in Machine Design, by *E. P. Pollitt*, Armour Research Foundation (Paper No. 59—A-134)

A Discussion of the Vibration Characteristics of a Simple Mechanical Connection, by *A. J. Sorensen, Jr.*, Gen. Motors Corp. (Paper No. 59—A-41)

MAINTENANCE SESSIONS

TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Aviation

See Aviation III

I THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Management and Process Industries

Training on a Process Simulator

[4] To be presented by abstract.

Part 1—Training on a Process Simulator, by *E. O. Carmody*, Carmody Corp., and *F. L. Lichtenfels*, Standard Oil Co. (Ohio) (Paper No. 59—A-218)

Part 2—Process Simulation Units for Training, by *F. L. Lichtenfels*, The Standard Oil Co. (Ohio) (Paper No. 59—A-205)

MANAGEMENT SESSIONS

MONDAY, NOVEMBER 30 9:30 a.m.

Jointly with Human Factors Group and Human Factors Society

See Human Factors I

MONDAY, NOVEMBER 30 2:30 p.m.

Jointly with Human Factors Group and Human Factors Society

See Human Factors II

MONDAY, NOVEMBER 30 2:30 p.m.

Jointly with Process Industries

See Process Industries I

I TUESDAY, DECEMBER 1 9:30 a.m.

Management of the Engineering Function

Modernized Engineering Organization, by *C. E. Paules*, Esso Res. & Engrg. Co. (Paper No. 59—A-245)

The Administration of Research and Development Projects, by *H. L. Mills*, Gen. Elec. Co. (Paper No. 59—A-246)

Utilizing Industrial Engineering in Engineering Management, by *J. L. Rigassio*, Newark College of Engrg. (Paper No. 59—A-244)

II TUESDAY, DECEMBER 1 2:30 p.m.

Engineers in Management

Academic Preparation for Engineers in Management, by *O. S. Carliss*, The Yale & Towne Mfg. Co. (Paper No. 59—A-248)

Some Attitude and Personality Characteristics of Engineers in Industry, by *Richard Renck*, Univ. of Chicago (Paper No. 59—A-247)

Shortcomings Vs. Requirements of Engineers in Management,[1] by *T. S. Coldewey*, St. Joe Paper Co.

THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Maintenance and Process Industries

See Maintenance

MATERIALS HANDLING SESSIONS

I WEDNESDAY, DECEMBER 2 9:30 a.m.

Palletless Warehousing as Applied to Case Goods,[1] by *I. M. Footlik*, Irving M. Footlik & Assoc.

Creative Engineering: The New Dimension in Materials Handling,[1] by *C. W. Drake*, Lehigh Warehouse & Transportation Co.

II WEDNESDAY, DECEMBER 2 2:30 p.m.

The Manipulator: Its Design and Application, by *J. C. Somers*, Industrial Products Engrg. Co. (Paper No. 59—A-186)

Amortization and Determination of Savings of Material-Handling Features, by *Fred Schneider*, United Merchants & Mfgrs., Inc. (Paper No. 59—A-216)

THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Safety

See Safety

MECHANICAL ENGINEERING DEPARTMENT HEADS SESSION

I THURSDAY, DECEMBER 3 2:30 p.m.

Panel Discussion: Policy to Guide Educators in Shaping Education of Mechanical Engineers in Future

Report of Studies by Mechanical Engineering Department Heads

Views of Mechanical Engineers in Industry

MECHANICAL PRESSURE ELEMENTS SESSION

I MONDAY, NOVEMBER 30 9:30 a.m.

Jointly with Instruments and Regulators

Bourdon Tube Deflection Characteristics,[1] by *P. G. Exline*, Exline Engrg. Co.

Analysis of Annular Shells With Applications to Welded Bellows, by *M. Hetényi* and *R. J. Timms*, Northwestern Univ. (Paper No. 59—A-175)

METALS ENGINEERING SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Fatigue

Low-Cycle Fatigue of Two Nickel-Base Alloys by Thermal Stress Cycling, by *F. J. Mehringer* and *R. P. Feglar*, Gen. Elec. Co. (Paper No. 59—A-58)

Cyclic Dependent Stress Relaxation of A-286 Alloy, by *A. S. Ross*, Boeing Airplane Co., and *JoDean Morrow*, Univ. of Illinois (Paper No. 59—A-116)

The Stability of Metals Under Cyclic Plastic Strain, by *L. F. Coffin, Jr.*, Gen. Elec. Co. (Paper No. 59—A-100)

II MONDAY, NOVEMBER 30 2:30 p.m.

Jointly with Plastic Flow of Metals

Plastic Flow and Fracture

Burst Strengths and Deformations of Welded Composite Turbine Wheels as Related to Weld Quality and Plasticity Calculations, by *A. G. Holms* and *A. J. Repko*, NASA, Lewis Research Center (Paper No. 59—A-28)

Roll-Force and Torque Coefficients for Hot-Strip Steel Mill, by *B. N. Garudachar*, Marquette Univ., and *H. A. Peterson*, Univ. of Wisconsin (Paper No. 59—A-153)

Steady-State Creep of a Thick Walled Cylinder Under Combined Axial Load and Internal Pressure, by *Iain Finnie*, Shell Development Co. (Paper No. 59—A-57)

III TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Effect of Temperature

Elevated Temperature Behavior

Some Observations on the Extrapolation of High-Temperature Ferritic Steel Data, by *R. M. Goldhoff*, Gen. Elec. Co. (Paper No. 59—A-133)

The Creep-Rupture Properties of 80 Nickel-20 Chromium Alloys, by *Robert Widmer* and *N. J. Grant*, M.I.T. (Paper No. 59—A-119)

The Extrapolation of Families of Curves by Recurrence Relations, With Application to Creep-Rupture Data, by *Alexander Mendelson* and *S. S. Manson*, NASA, Lewis Research Center (Paper No. 59—A-155)

IV TUESDAY, DECEMBER 1 2:30 p.m.

Jointly with Effect of Temperature

Elevated Temperature Behavior

Plasma-Flame-Spraying Equipment Development, by *R. M. Nadler*, Metallizing Engrg. Co. Inc. (Paper No. 59—A-236)

The Role of Atmosphere on the Creep-Rupture Behavior of 80 Nickel-20 Chromium Alloys, by *Robert Widmer* and *N. J. Grant*, M.I.T. (Paper No. 59—A-122)

Survey of Various Special Tests to Determine Elastic, Plastic and Rupture Properties at Elevated Temperatures, by *Frank Garofalo*, U. S. Steel Corp. (Paper No. 59—A-112)

[1] Papers available at Meeting.

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Copies of papers listed in this program as "Paper available at Meeting" will not be available in advance of the meeting because the review of these manuscripts had not been completed when the program went to press.

The January, 1960, issue of Mechanical Engineering will contain a complete listing of all available papers.

WEDNESDAY, DECEMBER 2 9:30 a.m.

Jointly with Production Engineering

See Production Engineering IV

THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Power

See Power IV

THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Power

See Power V

NUCLEAR ENGINEERING SESSIONS

I TUESDAY, DECEMBER 1 9:30 a.m.

Advanced Pressurized Water Reactor,[1] by *C. T. Chave*, Stone & Webster Engrg. Corp., and *J. B. Anderson*, Combustion Engrg., Inc.

Heavy-Water Moderated Nuclear Power Plants, by *M. S. Silberstein*, *J. A. De Felice*, and *W. A. Loeb*, Nuclear Development Corp. of America, and *W. A. Chittenden*, Sargent & Lundy (Paper No. 59—A-185)

A Plutonium-Fueled Fast-Breeder Atomic Power Plant,[1] by *A. Amorosi*, Atomic Power Development Associates, Inc.

Another Step in Water-Reactor Plant Technology,[1] by *A. R. Jones*, Westinghouse Elec. Corp.

II WEDNESDAY, DECEMBER 2 9:30 a.m.

Boiling-Water Reactor Study,[1] by *W. A. Hartman*, Gen. Elec. Co., and *L. F. C. Reichle*, Ebasco Services, Inc.

The Pathfinder Nuclear Plant, by *C. B. Graham*, Allis-Chalmers Mfg. Co. (Paper No. 59—A-179)

Design Study of a 300 eMw Organic Cooled Reactor, by *Ralph Balent*, North American Aviation, Inc., *G. H. Bosworth* and *J. D. Plauchan*, Bechtel Corp. (Paper No. 59—A-178)

Operating Experience and Advanced Designs of Sodium Graphite Reactors, by *R. W. Dickinson* and *L. E. Glasgow*, North American Aviation, Inc. (Paper No. 59—A-192)

PETROLEUM SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

The Strength of Thick Cylinders Subjected to Repeated Internal Pressure, by *J. L. M. Morrison*, Univ. of Bristol, Bristol, England, *B. Crossland*, The Queen's Univ., Belfast, Northern Ireland, and *J. S. C. Parry*, Univ. of Bristol, Bristol, England (Paper No. 59—A-167)

The Grand Isle Sulfur-Mine Heating Plant and Underwater Sulfur Line Design, by *C. M. Cockrell*, Freeport Sulphur Co. (Paper No. 59—A-183)

The Theory of the Ideal Design of a Compound Vessel,[2] by *S. J. Becker*, Westinghouse Elec. Corp., and *L. Mollick*, Baldwin-Lima-Hamilton Corp. (Paper No. 59—A-125)

II TUESDAY, DECEMBER 1 9:30 a.m.

Economic Selection of Steam and Power Supplies for Refineries and Petrochemical Plants,[1] by *W. B. Wilson*, Gen. Elec. Co.

Integration of the Power-Recovery Gas Turbine With Fluid-Bed Processes, by *J. C. Dygert* and *I. S. Bjorklund*, Shell Development Co. (Paper No. 59—A-231)

Pump Standardization—A User's Concept, by *R. G. Jobe*, Shell Chemical Corp. (Paper No. 59—A-162)

III TUESDAY, DECEMBER 1 2:30 p.m.

Tube-Metal Temperatures for Structural Design, by *E. E. Ungar* and *L. A. Mekler*, Bolt Beranek & Newman, Inc. (Paper No. 59—A-166)

Influence Coefficients and Pressure-Vessel Analysis, by *G. D. Galletly*, Shell Development Co. (Paper No. 59—A-163)

Pressure-Vessel Over-Temperature Hazards,[1] by *G. P. Eschenbrenner*, *R. S. Eagle*, *J. J. Murphy*, and *D. B. Rossheim*, The M. W. Kellogg Co.

THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Fluid Meters, and Instruments and Regulators

See Fluid Meters I

THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Fluid Meters, and Instruments and Regulators

See Fluid Meters II

PLASTIC FLOW OF METALS SESSIONS

MONDAY, NOVEMBER 30 2:30 p.m.

Jointly with Metals Engineering

See Metals Engineering II

TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Production Engineering

See Production Engineering I

[2] Not presented orally.

POWER SESSIONS

TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Process Industries

See Process Industries II

WEDNESDAY, DECEMBER 2 9:30 a.m.

Marine

Thermal Instability in High-Speed Gearing, by *W. P. Welch* and *J. F. Boron*, Westinghouse Elec. Corp. (Paper No. 59—A-118)

The Distinguishing Aspects of Marine Engineering, by *G. L. West, Jr.*, Univ. of Michigan (Paper No. 59—A-202)

Advances in Steam Turbines for Marine Propulsion, by *A. D Somes*, Gen. Elec. Co. (Paper No. 59—A-263)

II WEDNESDAY, DECEMBER 2 2:30 p.m

Recent Boiler-Design Practice, by *E. G. Kispert* and *W. H. Rowand*, The Babcock & Wilcox Co. (Paper No. 59—A-176)

Industrial Boiler Design, by *T. B. Hurst* and *C. C. Hamilton*, The Babcock & Wilcox Co. (Paper No. 59—A-78)

The Critical and Two-Phase Flow of Steam, by *W. G. Stelts*, Westinghouse Elec. Corp. (Paper No. 59—A-223)

III WEDNESDAY, DECEMBER 2 8:00 p.m.

Pressure-Suppression Containment for Nuclear Power Plants, *C. C. Whelchel*, Pacific Gas & Elec. Co., and *C. H. Robbins*, Gen. Elec. Co. (Paper No. 59—A-215)

Integration of Turbine-Driven Boiler-Feed Pumps in Large Power Plants, by *E. L. Pace*, Gen. Elec. Co. (Paper No. 59—A-196)

Decentralized Peak-Shaving—Its Economic Significance to Electric Utilities,[1,2] by *C. W. Bary*, Philadelphia Elec. Co.

IV THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Metals Engineering

The Eddystone Research Story—Part 1

Water Treatment, Corrosion, and Internal Deposit Studies for Eddystone, by *R. C. Ulmer*, *H. A. Grabowski*, and *R. C. Patterson*, Combustion Engrg., Inc. (Paper No. 59—A-147)

Metallurgical Development for the Selection of Materials and Fabricating Techniques at Eddystone,[1] by *E. C. Chapman* and *R. E. Lorentz, Jr.*, Combustion Engrg., Inc.

A New Sensitive Temperature Detector for Use in High-Pressure Fluid Piping, by *D. Robertson*, Leeds & Northrup Co. (Paper No. 59—A-201)

Development of Floating Ring-Type Stuffing Boxes for Eddystone Boiler-Feed Pumps, by *Alexander Brkich* and *R. E. Allen*, Ingersoll-Rand Co. (Paper No. 59—A-259)

V THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Metals Engineering

The Eddystone Research Story—Part 2

Developments Associated With the Superpressure Turbine for Eddystone No. 1 of Philadelphia Electric Company,[1] by *W. E. Trumpler*, *E. A. Fox*, *A. F. Lebreton*, and *R. B. Williamson*, Westinghouse Elec. Corp.

Material Selection and Fabrication of Main Steam Pipe for 5000 psi and 1200 F Service at Eddystone No. 1,[1] by *R. H. Caughey* and *W. G. Benz, Jr.*, The M. W. Kellogg Co.

A Test to Anticipate the Performance of Steam Piping at 5000 psi and 1200 F, by *G. C. Wiedersum, Jr.*, Philadelphia Elec. Co. (Paper No. 59—A-230)

Research Problems Related to Production and Quality Control of Ultra-Pure Condensate Feedwater for Eddystone Station, by *J. A. Levendusky* and *V. J. Calise*, Graver Water Conditioning Co. (Paper No. 59—A-240)

Pilot-Plant Water Studies for Eddystone Station, by *F. N. Megahan*, Philadelphia Elec. Co. (Paper No. 59—A-260)

[1] Paper available at Meeting.
[2] Not presented orally.

VI FRIDAY, DECEMBER 4 9:30 a.m.

A Steam-Testing Facility, by *C. A. Meyer*, *C. E. Seglem*, and *J. T. Wagner*, Westinghouse Elec. Corp. (Paper No. 59—A-88)

The Calculation of Incompressible Flow Through Turbine Cascades,[1] by *H. F. Bueckner*, Univ. of Wisconsin, and *H. C. Schnackel*, Gen. Elec. Co.

Recent Improvements in Load Capacity of Large Steam-Turbine Thrust Bearings, by *H. C. Bahr*, Gen. Elec. Co. (Paper No. 59—A-139)

POWER TEST CODES SESSION

I TUESDAY, DECEMBER 1 8:00 p.m.

Jointly with Fluid Meters

Temperature Measurement in Moving Fluids, by *R. P. Benedict*, Westinghouse Elec. Corp. (Paper No. 59—A-257)

Throat-Tap Nozzles Used for Accurate Flow Measurements, by *K. C. Cotton* and *J. C. Westcott*, Gen. Elec. Co. (Paper No. 59—A-174)

Theory and Application of Strain-Gage Torque-Measuring Devices,[1] by *H. E. Lockery*, Baldwin-Lima-Hamilton Corp.

PROCESS INDUSTRIES SESSIONS

I MONDAY, NOVEMBER 30 2:30 p.m.

Jointly with Management

Engineering Application of Computers, by *H. D. Irwin*, E. I. du Pont de Nemours & Co., Inc. (Paper No. 59—A-180)

Panel Discussion: The Engineering Graduate's Familiarity With Computers

Are today's engineering graduates prepared to use computers effectively for engineering problem analysis? The panel is bringing a status report covering (1) What types of problems are being solved by computers today, (2) What types of computing machinery are being used to solve engineering problems, (3) College's role in training the engineer to use computers in engineering problem solving, and (4) Industry's role in training the engineer to use computers for problem solving.

Panel Members
S. H. Crandall, M.I.T.
L. D. Conta, Univ. of Rochester
Fred Landis, New York Univ.

II TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Power

Some Applications of the Low-Level Economizer, by *J. H. Potter*, Stevens Inst. of Tech., and *R. C. King*, Gibbs & Hill, Inc. (Paper No. 59—A-222)

The Low-Level Economizer, by *Stanley Jewson*, The Green Fuel Economizer Co., Inc. (Paper No. 59—A-226)

Flash Evaporators for the Production of Boiler Make-Up in Power Plant Cycle, by *E. F. Stalcup*, *E. F. Coxe*, and *R. L. Coit*, Westinghouse Elec. Corp. (Paper No. 59—A-203)

III TUESDAY, DECEMBER 1 2:30 p.m.

Chemical Nickel Coating on a Large Scale by the Kanigen Process,[1] by *W. J. Crehan*, Gen. American Transportation Corp.

Some Operating Experiences at a Sewage-Sludge-Drying Plant,[1] by *H. A. Naylor, Jr.*, Whitman, Requardt & Associates

Effect of Transient Loads on Refrigerated-Space Temperature, by *C. F. Kayan*, Columbia Univ. (Paper No. 59—A-181)

THURSDAY, DECEMBER 3 9:30 a.m.

Jointly with Maintenance and Management

See Maintenance

PRODUCTION ENGINEERING SESSIONS

I TUESDAY, DECEMBER 1 9:30 a.m.

Jointly with Plastic Flow of Metals

Microanalysis of Steel-Rule Cutting,[1] by *D. F. Eary*, Gen. Motors Inst.

Drawability of Sheet Aluminum, Alloy 54S7,[1] by *R. W. Bund*, Gen. Motors Inst.

II TUESDAY, DECEMBER 1 2:30 p.m.

Design Concept on Welded Steel Lathe,[1] by *G. M. Sommer*, Clearing Machine Corp.

Facilities for Handling and Welding Assemblies in the Machinery Industry,[1] by *John Mikulak*, Worthington Corp.

III TUESDAY, DECEMBER 1 8:00 p.m.

Analysis of Power Spinning of Cones, by *B. Avitzur*, Ford Motor Co., and *C. T. Yang*, Univ. of Michigan (Paper No. 59—A-173)

The Deformation Process in Metal Cutting, by *W. J. McDonald* and *B. F. Murphey*, Minnesota Mining & Mfg. Co. (Paper No. 59—A-165)

Some Problems of Press Forging Lead and Aluminum, by *A. G. MacDonald*, *S. Kobayashi*, and *E. G. Thomsen*, Univ. of California (Paper No. 59—A-164)

IV WEDNESDAY, DECEMBER 2 9:30 a.m.

Jointly with Metals Engineering

Tensile and Short-Time Creep Properties of N-155 Alloy Sheet, by *E. C. Bernett*, The Marquardt Corp. (Paper No. 59—A-27)

A Photoelastic Analysis of Machining Stresses on Rake Face,[2] by *Eiji Usui* and *Hidehiko Takeyama*, The Government Mech. Lab., Tokyo, Japan (Paper No. 59—A-37)

Correlation of Bendability of Materials With Their Tensile Properties, by *C. T. Yang* and *J. Datsko*, Univ. of Michigan (Paper No. 59—A-110)

V WEDNESDAY, DECEMBER 2 2:30 p.m.

Jointly with Safety

Flow Turning to Increase Strength, Save Weight, and Reduce Costs,[1] by *J. H. Peters*, Pratt & Whitney Aircraft, Div. of United Aircraft Corp.

Investigation of Hot Forming Internal Threads,[1] by *J. F. McAuliffe*, Pratt & Whitney Co., Inc.

Planning Human Environment Into Industrial Processes,[1] by *L. B. Wocholski*, Gen. Motors Inst.

VI WEDNESDAY, DECEMBER 2 8:00 p.m.

Comparisons Between the Shearing Properties of Alpha Brass as Derived From the Cutting Process and From Static and Impact Torsion Tests,[2] by *Sze-Shen Chang*, Natl. Engrg. Lab., Glasgow, Scotland, and *W. B. Heginbotham*, The Univ. of Nottingham, Nottingham, England (Paper No. 59—A-38)

The Role of Friction in Metal Cutting, by *S. Kobayashi* and *E. G. Thomsen*, Univ. of California (Paper No. 59—A-132)

A Critical Comparison of Metal-Cutting Theories With New Experimental Data, by *S. Kobayashi*, Univ. of California, *R. P. Herzog*, Aerojet-General Corp., *D. M. Eggleston* and *E. G. Thomsen*, Univ. of California (Paper No. 59—A-131)

New Developments in the Theory of the Metal-Cutting Process, by *Paul Albrecht*, The Cincinnati Milling Machine Co. (Paper No. 59—A-243)

VII THURSDAY, DECEMBER 3 9:30 a.m.

Decision for Automatic Handling,[1] by *E. R. Allan, Jr.*, Gen. Motors Corp.

Feedback in Industrial Operations, by *R. E. McGarrah*, Harvard Business School (Paper No. 59—A-126)

New Developments in Plant-Layout Techniques, by *J. M. Apple*, Clarke Floor Machine Co. (Paper No. 59—A-204)

PROFESSIONAL PRACTICE COMMITTEE SESSION

I THURSDAY, DECEMBER 3 2:30 p.m.

Symposium

A New Look at Architects' and Engineers' Professional Liability (Not to be printed), by *V. O. Schinnerer*, Victor O. Schinnerer & Co., Inc.

Why and How to Get a Case Book on Engineering Ethics (Not to be printed), by *N. A. Christensen*, Cornell Univ.

Foreign Work (Not to be printed), by *B. R. Value*, Seelye, Stevenson, Value & Knecht

The Practice of Consulting Engineering in Canada (Not to be printed), by *G. L. Wiggs*, Wiggs Walford Frost & Lindsay, Consulting Engineers, Montreal, Que., Canada

PROPERTIES OF STEAM SESSION

I WEDNESDAY, DECEMBER 2 2:30 p.m.

Progress Report on Measurement of Viscosity of Steam (Not to be printed), by *Joseph Kestin*, Brown Univ.

Progress Report on the Thermal Conductivity of Steam (Not to be printed), by *F. G. Keyes*, M.I.T.

Acoustical Properties of Steam (Not to be printed), by *R. B. Lindsay*, Brown Univ.

Preliminary Values of the Joule-Thomson Coefficients for Water at Elevated Pressures and Temperatures (Not to be printed), by *B. H. Sage*, California Inst. of Tech.

RAILROAD SESSIONS

THURSDAY, DECEMBER 3 9:30 a.m.

Progress in Railway Mechanical Engineering 1958–1959 (Report of Committee RR6 Survey, by *D. R. Meier*, chairman; *R. M. Coultas*, *H. G. McLean*, and *A. G. Dean*),[1] to be presented by *D. R. Meier*, Gen. Elec. Co.

Stresses in Wrought-Steel Wheel Rims and Their Relation to Wheel Life, by *M. S. Riegel*, American Iron & Steel Inst. (Paper No. 59—A-241)

The Application of Diesel Engines to Industrial Diesel-Electric Locomotives, by *R. W. Barrell*, Gen. Elec. Co. (Paper No. 59—A-227)

II THURSDAY, DECEMBER 3 2:30 p.m.

Dynamic Stresses in Traction Motors Resulting From Defective Gearing, by *E. E. Greene*, Gen. Elec. Co., and *M. A. Pinney*, The Pennsylvania Railroad Co. (Paper No. 59—A-13)

Mobile Reflectoscope Inspection of Railway Car Axles Under Rolling Equipment on the Chesapeake and Ohio Railway, by *M. F. Melrose* and *T. E. De Vilbiss*, Chesapeake & Ohio Railway Co. (Paper No. 59—A-228)

Study of Vibration Frequencies Under Impact Conditions, by *G. H. Newcomer*, Assn. of American Railroads (Paper No. 59—A-250)

III FRIDAY, DECEMBER 4 9:30 a.m.

Symposium on Cushioned Underframe Design

Cushioning Requirements for Adequate Lading Protection,[1] by *W. H. Peterson*, Pullman, Inc.

The Hydracushion Underframe and Its Contribution to the Reduction of Lading Damage, by *S. M. Houston*, Southern Pacific Co. (Paper No. 59—A-198)

The Santa Fe Shock-Control Car, by *T. T. Blickle*, Atchison, Topeka & Sante Fe Railway Co. (Paper No. 59—A-221)

Impact as Related to Freight Car and Lading Damage, by *W. E. Baillie*, Nat. Malleable & Steel Castings Co. (Paper No. 59—A-249)

Increased Cushioning Capacity—A Requirement of Tomorrow's Freight Cars, by *R. E. Abbott*, Assn. of American Railroads, and *H. K. Lanning*, Atchison, Topeka & Santa Fe Railway Co. (Paper No. 59—A-224)

RUBBER AND PLASTICS SESSIONS

I MONDAY, NOVEMBER 30 9:30 a.m.

Uniform Two-Way Orientation of Plastic Films, by *M. O. Longstreth* and *Turner Alfrey, Jr.*, The Dow Chemical Co. (Paper No. 59—A-113)

Videne—A New Polyester Laminating and Surfacing Film,[1] by *C. W. Taylor*, Goodyear Tire & Rubber Co.

[1] Paper available at Meeting.

Plastics in Construction and Agriculture, by *T. E. Werkema*, The Dow Chemical Co. (Paper No. 59—A-261)

Plastics Developments: 1958–1959,[1] by *Lois W. Brock*, The General Tire & Rubber Co.

II MONDAY, NOVEMBER 30 2:30 p.m.

Plastic-Pipe Standards (Not to be printed), by *Gordon Kline*, Nat. Bur. of Standards, Dept. of Commerce

Polyethylene Pipe Progress,[1] by *Alfred Stockfleth*, E. I. du Pont de Nemours & Co., Inc.

Factors Affecting the Long-Term Performance of Polyethylene Plastic Pipe,[1] by *W. P. Acton*, Hercules Powder Co.

Rubber Developments: June, 1957–June, 1959,[1] by *Leora E. Straka*, General Tire & Rubber Co.

SAFETY SESSIONS

WEDNESDAY, DECEMBER 2 2:30 p.m.

Jointly with Production Engineering

See Production Engineering V

I THURSDAY, DECEMBER 3 2:30 p.m.

Jointly with Materials Handling

Planning Materials-Handling Safety Into the Plant Layout, by *J. W. Hall*, Westinghouse Elec. Corp. (Paper No. 59—A-252)

Materials Handling Without Accident, by *J. C. Webb*, Jervis B. Webb Co. (Paper No. 59—A-251)

An Engineering Approach to Materials-Handling Safety, by *W. J. Byrne*, Walter J. Byrne & Co., Inc. (Paper No. 59—A-253)

SOLAR ENERGY SESSION

I FRIDAY, DECEMBER 4 9:30 a.m.

Jointly with Heat Transfer

Solar Air Conditioning Using an Ammonia-Water Absorption-Refrigeration System,[1] by *E. A. Farber* and *F. M. Flanigan*, Univ. of Florida, and *M. M. Eisenstadt*, The Martin Co.

Solar Turbo Power-plant Design, by *D. B. Mackay*, North American Aviation, Inc. (Paper No. 59—A-74)

1959 Progress Report on Solar Energy Applications,[1] by *J. I. Yellott*, Yellott Engrg. Associates, Inc.

Analysis of Solar Furnace Performance in Mechanical Testing at Extremely High Temperatures, by *G. S. Leon* and *M. E. Shank*, M.I.T. (Paper No. 59—A-79)

TEXTILE ENGINEERING SESSION

FRIDAY, DECEMBER 4 9:30 a.m.

Mechanical Properties of Textile Materials, by *E. J. Stavrakas*, Fabric Research Labs., Inc. (Paper No. 59—A-99)

The Interaction of Textile Structures and High-Speed Textile Processes, by *H. M. Morgan*, Fabric Research Labs., Inc. (Paper No. 59—A-115)

Use of Textile Machines as Research Tools, by *J. F. Bogdan*, North Carolina State College (Paper No. 59—A-220)

PLANT TRIPS

TUESDAY, DECEMBER 1 9:30 a.m.

National Aviation Facilities Experimental Center—Atlantic City Airport

A visit to the experimental center of NAFEC—a joint project of civil and military aviation interests to do research and development on equipment for automatic flight and landing of airplanes. Visitors will see the newest types of control and lighting equipment under test.

WEDNESDAY, DECEMBER 2 9:00 a.m.

Owens-Illinois Glass Company, Bridgeton, N. J.

A visit to the largest glass-container factory in the world. Here are manufactured glass containers ranging in size from vials of a few cubic centimeters capacity to bottles of one gallon capacity—vials, jars, and bottles for pharmaceuticals, foods, beverages, and many other products. Visitors will see in operation the automatic conveyers and machinery for the handling and mixing of the raw materials, the making of the glass, the molding of the containers and the inspection, selection, and packing of the final product. Special processes for the coloring and decoration of the various containers will also be shown.

Owens-Illinois manufactures, also, the corrugated board cartons used for shipment of the glass containers and, in turn, by the purchasers for shipment of their products.

This is a modern factory and should be of interest to engineers engaged in the manufacture and use of automatic process machinery.

THURSDAY, DECEMBER 3 10:30 a.m.

Brighton Florists, Linwood, N. J.

The women of the Auxiliary are planning to visit this nearby orchid farm, followed by lunch at Sea View Country Club. The men are invited to join this group.

WOMEN'S PROGRAM

SUNDAY, NOVEMBER 29

1:00 p.m.	Registration
4:00 p.m.	"Early Bird" Party
8:30 p.m.	Hotel Concert

MONDAY, NOVEMBER 30

8:00 a.m.	Registration
8:30 a.m.	Coffee Hour
12:15 p.m.	President's Luncheon
2:30 p.m.	Auxiliary Workshop
8:00 p.m.	Variety Show

TUESDAY, DECEMBER 1

8:00 a.m.	Registration
8:30 a.m.	Coffee Hour
8:30 a.m.	National Board Breakfast and National Board Meeting
11:00 a.m.	Tour of Chalfonte-Haddon Hall kitchen
4:00 p.m.	Tea Dance
9:00 p.m.	Bridge Party

WEDNESDAY, DECEMBER 2

8:00 a.m.	Registration
10:00 a.m.	Annual Business Meeting of the Auxiliary
1:00 p.m.	Annual Luncheon Speaker: *Emilie Jacobson*, journalist, lecturer, and actress Subject: **Laughter—Freedom's Secret Weapon**
8:00 p.m.	Movie Night

THURSDAY, DECEMBER 3

8:00 a.m.	Registration
8:30 a.m.	Coffee Hour
10:30 a.m.	Trip to Brighton Florists, Somer Point
1:00 p.m.	Luncheon at Sea View Country Club
6:00 p.m.	Social Hour
7:00 p.m.	Annual Banquet
10:00 p.m.	Dance

FRIDAY, DECEMBER 4

8:00 a.m.	Registration
8:30 a.m.	Coffee Hour

COLLEGE REUNIONS

Information about time and place may be obtained at the Registration Headquarters at the Chalfonte-Haddon Hall Hotel.

ASME Technical Development Committee Releases First Report

Magnetohydrodynamics, electric automobiles, energy storage, nuclear fusion, water resources, among topics covered

THE future will take care of itself is not a philosophy to which The American Society of Mechanical Engineers has ever subscribed. Thus in pursuit of a strong technical program, the Society established the Technical Development Committee, in 1956, to watch and evaluate the growth of scientific and engineering knowledge; to see where the Society could best participate in new technical fields; and to recommend the formation of new groups within ASME, when necessary, to serve the Society's needs in increasing and expanding fields of the future.

The Planners

To chart this forward-looking plan the Society enlisted, with J. W. Barker as chairman, the following: R. C. Allen, A. D. Bailey, E. G. Bailey, H. L. Dryden, J. A. Hutcheson, C. F. Kettering, W. E. Reaser, L. N. Rowley, Jr., Philip Sporn, G. B. Warren, Clyde E. Williams, and J. I. Yellott.

"Without a strong technical program," said Dr. Barker, discussing the Committee's work, "the Society cannot exist."

So, when the Committee took up its work in October of 1956, it addressed itself to the study of such ponderous problems as atomic energy, solar energy, and long-range weather predictions.

Quietly, the Committee worked along to promote the greatest freedom of expression, and this year for the first time we have a report.

The personnel of the Committee has changed—"Boss" Ket is gone. Dr. Barker, Dr. Dryden, Alex Bailey, and W. E. Reaser have resigned because of new duties and assignments. The Committee, however, has welcomed to its membership John J. Grebe, William Francis Gibbs, and S. C. Hollister. Current chairman of the Committee is R. C. Allen.

What Did They Find?

Power—Magnetohydrodynamics. The work on thermonuclear fusion, whereby a gas at high temperature becomes a good conductor as the result of a high degree of ionization, has directed consideration of one of the Committee members toward the possibility of employing, in reverse, the basic principle of the Faraday pump in which coal-furnace gases, made partially conducting by a special additive, can be employed to generate a direct current of electricity by movement at high velocity through a high intensity magnetic flux.

The exhaust gas from the power-generating flow channel is employed to preheat the combustion air followed by the generation of steam in a conventional power cycle.

This intriguing proposal, if a reliable design can be worked out, offers a potential improvement in over-all plant thermal efficiency from the present upper level of, perhaps, 40 per cent up to a possible 55 per cent, or even higher.

There are many problems to be solved in the development of the MHD power concept before feasibility can be assured. Among these is the question of energy relations which may result from the partial dissociation of the cycle gases.

Automotive—Electric Automobiles. The Committee has given consideration to the propulsion of motor cars which are presently such an essential part of the American economy and mode of living. It seems to be well established that the proved or known resources of liquid fuels are of relatively few decades duration; at least the time is not far distant when substantial fuel-price increases can be expected.

It has been pointed out that the annual fuel bill for our nearly 70 million motor vehicles is about eight times the cost of fuel used in our central stations generating electric power, while the heating value of the fuel actually consumed in our motor cars is only about the same as the corresponding heating value of the fuel burned in our power stations.

When it comes to horsepower ratings, even at a conservative figure like 60 hp, we arrive at a total rating of our rubber-tired vehicles which is approximately 20 times the rated capability of our electric-power generating plants.

The Committee has been following with interest the reports which are appearing with increasing frequency in the technical press concerning the small, lightweight, electric-drive motor car for town and suburban use. (MECHANICAL ENGINEERING, August, 1959, pp. 77–79.) Such vehicles with presently available batteries are reported to have sufficient endurance in miles per charge to handle the great majority of the city and suburban traffic for the large cities of this country.

The Committee has reviewed such information on conventional battery developments as it has been able to secure, without finding promise of rapid advances in the directions of reduced weight and cost in immediate future.

Automotive—General. The possibility of the fuel cell as an energy source for automotive power has been discussed a number of times. The work of Bacon in England, Davtyan in Russia, and various investigators in the United States have been reviewed. The most promising type of fuel cell for present application would utilize oxygen and hydrogen gases stored under pressure in the usual steel cylinders, the gases to be produced by the use of electric power or by chemical means, depending on the future economics involved.

The Committee has noted the recent articles describing a land or water vehicle which is supported directly on an air cushion and which should, therefore, encounter very little frictional resistance from the medium over which it is traveling. (MECHANICAL ENGINEERING, February, 1959, cover, pp. 82–83; July, 1959, p. 66.)

Another development which holds promise for the future, not only in the automotive field, but in air pollution as well, is a new internal-combustion engine which is predicted to operate with complete combustion gases without noxious or objectionable odors in the exhaust. Further, it has been estimated that the potential fuel savings which can be realized with this development may be of the order of 20 to 25 per cent. This savings in fuel, if generally applied to a 10 billion dollar annual automotive-fuel expenditure, should be more than 2 billion dollars, which exceeds the total annual fuel bill today for central-station operation.

Energy Storage. The subject of energy storage has occupied an appreciable time in the deliberations of the Committee.

The Committee frequently has reviewed reports of new electrical storage battery developments. While statements have been made to the effect that batteries of one third the size, and half the weight of lead batteries have been developed, and also that such batteries will take a charge in less time than present lead batteries, these battery types have not appeared on the industry market probably because of their substantially increased cost.

In addition to the possibilities of the fuel cell as a source of energy for auto-

mobiles, the Committee has also discussed the fuel cell as a possible general source of electrical energy. It is of interest that Sir William Grove, some 120 years ago, showed that the process of electrolysis can be reversed and oxygen and hydrogen gases made to recombine with very little increase in temperature in the presence of a catalyst, and in the process of recombining, generate an electric current. This process avoids the "heat sink" loss and the Carnot cycle efficiency limit, which is inescapable in conventional heat cycles. (See MECHANICAL ENGINEERING, March, 1959, pp. 63–65; August, 1959, pp. 64–68.)

The ultimate target would be the use of pulverized coal and atmospheric air in a suitable environment with a catalyst whereby oxidation can be accomplished without the usual form of combustion and electric power directly generated.

The Committee has discussed numerous other means of energy storage. The hydraulic system, which is popularly known as pumped hydro and which utilizes the "pump turbine," is now well accepted in the power-generation industry.

Power From Fusion. In 1957 the Committee agreed that a book on nuclear fusion as a source of energy should be prepared and made available to power engineers. The Chairman of the Committee communicated with the Chairman of the Atomic Energy Commission and found that an excellent book was being prepared on Project Sherwood, the U. S. Program on controlled fusion, under the authorship of Dr. Amasa S. Bishop.

The book, which first appeared at the Atoms for Peace Conference at Geneva in September, 1958, contains a wealth of information on the present state of controlled thermonuclear fusion development.

The present activity of the Committee in this area is the reviewing of reports and the digesting of current literature with an eye toward the future activities of the Society in this field. The Committee is endeavoring to secure speakers for ASME meetings from the thermonuclear development centers of the Atomic Energy Commission. (MECHANICAL ENGINEERING, August, 1959, pp. 52–60.)

Underground Explosions of Nuclear Devices. Technical information released by the U. S. Atomic Energy Commission coupled with supplementary studies made by Committee members, have aroused a great deal of interest in the possibility of underground explosions of nuclear devices, particularly hydrogen bombs, in environments which may be employed for the generation of power. Several of these experimental explosions have been carried out, and, while limited to a maximum equivalent energy of 23 kilotons of TNT, have shown that there is a possibility of forming, deep in the earth, hugh cavities which will contain the tremendous heat released from such explosions and which can be supplied with water from the earth's surface to be delivered to the surface again in separate conduits as high-pressure, high-temperature steam. The Committee will continue to watch these future developments.

An outstanding item of interest is the price list issued by the Atomic Energy Commission where the purchase price of nuclear devices is tabulated and made available to industry. A 5-megaton bomb can be purchased for $1 million including safety studies, placement, and detonation. Such a device can supply thermal energy at the rate of five cents per million Btu, a figure which has not been approached by any other man-made source of heat. An extension of the present curve of prices indicates still lower costs of thermal energy for nuclear devices of higher outputs.

In addition to the possibilities in the direction of power generation, these underground explosions can be used for many other purposes, including: Breaking up and crushing underground ore deposits, releasing oil from tar sands, creating underground reservoirs for water supplies, and building of harbors, dams, and canals.

Preliminary surveys indicate substantial cost reductions below current costs of existing conventional engineering methods for these operations.

Water Resources. The relation of water resources to the national economy has been in the past a subject area for civil engineers and geologists, but there is a growing recognition that some of the important future development and solutions will be essentially in the field of mechanical engineering. As a result of increasing interest in water resources and the use of water in industry the Committee arranged two sessions at the 1959 ASME Semi-Annual Meeting, held in St. Louis, Mo. Four papers were presented and Dr. G. H. Higgins, the principal luncheon speaker, described "Project Plowshare," the program directed toward the study of the industrial application of underground nuclear explosions.

An article based on these five papers will be published in a subsequent issue of MECHANICAL ENGINEERING.

To further promote the study of water resources by the Society, the Committee shall establish a water development committee to study methods of economically converting salt water to fresh water.

What Can They Do?

The report related the Committee's discussions on such varied topics as air pollution; algae as a source of food and fuel; the problems involved in securing prompt and effective service in connection with the translation of technical articles, with particular reference to material from the Soviet Union. In the field of physics, the theories of a prominent engineer are under consideration regarding the physics of empty space, one phase being the possibility that radiant energy is being continuously turned back into matter; also the Committee has discussed a new theory which seems to give a logical explanation of the relative magnitudes of fundamental particles with the possibility of the construction of a periodic table into which the 30 or more elementary particles seem to find their places in a logical and regular pattern; novel sources of energy; and weather control also have been studied. From the discussions on railroads the need for a concerted attack on heavy traction engineering evolved. Much can be done to promote lower costs, higher speeds, greater safety, and high operating efficiency in rail transportation in the United States.

The Committee urges that railroad studies on the feasibility of reducing operating costs and increasing efficiency through the development of a comprehensive system of automation be undertaken. In addition to the economic potential, operational safety could be improved substantially by the employment of "fail-safe" systems less dependent upon the human element. Another is the question of motive power. It is quite possible that future extensive electrification may supplant much, if not most, of the present diesel power. Another subject requiring intensive re-evaluation is that of passenger traffic in relation to bus lines and air transport.

The report concludes with this suggestion by the Committee: A review of the list of recipients of the Nobel Prizes in physics and chemistry and their achievements would bring to light individuals who could be invited to contribute important papers or lectures before the Society. Their accomplishments could be reviewed for possible applications in the field of mechanical engineering.

Further, the Committee hopes to recommend speakers who can present important engineering and scientific developments, possibly through the medium of the Thurston Lectures.

ASME Acts to Shorten Time-Lag Between Scientific Discoveries and Application

President Warren names F. B. Turck to co-ordinate efforts

A PROGRAM to chop "the dangerous time-lag" between scientific discoveries and their practical application was announced early in September by The American Society of Mechanical Engineers.

Glenn B. Warren, ASME President, called such delays "our greatest single handicap in competing with the Soviet and other state-controlled industry."

"There is no real evidence that Russian science is seriously outpacing ours," said Mr. Warren. "But it may well be true that the Russians are putting their scientific progress to work faster than we are."

The man chosen to organize efforts to speed up the application of new scientific knowledge is Fenton B. Turck, Fellow ASME, and a leading consulting engineer in New York City.

"Half the billions we pour into scientific research are wasted until we discover how to shorten the science pipeline to the American people," Mr. Turck declared. "The flow of scientific findings to industry now runs like molasses.

"Scientists must think more in terms of putting their discoveries to work. And engineers must be more alert to use improved products and techniques, be less resistant to change.

"This time-lag has long been recognized. But unless we act now, it could become disastrous for all of us," Mr. Turck said.

Mr. Turck will enlist heads of industrial concerns, leading engineering and scientific educators, prominent engineers and research foundations to help discover means of speeding transmission of new information from laboratories to the factory floor.

Mr. Turck stated, "Examples are legion. Fundamental principles that led to penicillin were discovered back in 1870—but it took more than seven decades to put it to work. There are a whole flock of new metals—'wonder metals'—that we've developed, but haven't yet put to work. Cadmium, magnesium, barium, titanium, and beryllium offer tremendous possibilities—when engineers finally 'discover' them. The physical theory of nuclear fission was well known to scientists for years before engineers built the plants that produced practical quantities of uranium and plutonium.

"For a long time, students of technology have recognized that much of our industrial lead over Europe really stemmed from the comparatively free and flexible interchange of scientific and technological information in our industry," Mr. Turck added. "But now, the controlled economy countries are doing us one better.

"Despite the fact that there are thousands of publications, conferences, symposiums, technical digests, and other media of communication, some discoveries are left on the shelf for long periods of time while industry operates with inferior techniques. It is this tragic waste that we are attempting to reduce."

Mr. Turck, who is head of his own consulting engineering firm in New York City, is a former industrial executive who has pioneered in the application of scientific principles to industrial problems. He is the founder of the Turck Lectures at Yale's Engineering School. He is a recipient of the Netherlands "Order of Officer of Orange of Nassau" for his contributions in the international field.

In announcing the appointment of Mr. Turck, Mr. Warren pointed out that the task of channelling scientific information has been complicated in recent years by the increased volume of research results. ASME alone, he said, has in the past decade been forced to increase from 3500 to 6500 the number of pages published in its journals and periodicals, to accommodate the increased flow of technical literature. During the same period, he added, major national conferences sponsored by the Society has jumped from 12 a year to 26.

These channels of communication, he said, "are becoming over-burdened and unmanageable because of their bulk. It is with this in mind that we are now seeking new channels, and new techniques, perhaps even a way to develop new attitudes in key engineers and scientists to make certain that this critical partnership between research and application does not break down, and is, in fact, strengthened and nourished."

National Automatic Control Conference, Nov. 4–6, 1959, Sheraton-Dallas Hotel, Dallas, Texas

Sponsors. Sponsored by the Institute of Radio Engineers Professional Group on Automatic Control (IRE-PGAC), with official participation by the American Institute of Electrical Engineers (AIEE), the Instrument Society of America (ISA), and the IRE Professional Group on Industrial Electronics; and with the co-operation of the Instruments and Regulators Division, The American Society of Mechanical Engineers, and the Electrical-Engineering Department of Southern Methodist University. Principal Conference officers are Louis B. Wadel, Chance Vough Aircraft, Inc., Chairman; George S. Axelby, Westingouse Electric Corporation, Technical Program Chairman; and John M. Salzer, Ramo-Wooldridge, Special Program Chairman.

Abstracts. Abstracts of all technical papers will be available at the Registration Desk. Anyone desiring an advance copy of abstracts may send a self-addressed stamped envelope to Mr. M. L. Barnett, Apt. 208, 6255 Oram St., Dallas, Texas.

Parallel Control System Components Conference. The Feedback Control Systems Committee of the AIEE (with other co-operating groups) is sponsoring a "Control System Components Conference," also at the Sheraton-Dallas Hotel, in parallel with the second and third day of the National Automatic Control Conference. Their technical sessions, marked "CSCC," are included in the program listings.

Dinner Meeting. Dr. Albert C. Hall, automatic control pioneer and currently Director of Research at the Martin Company, Denver, Colo., will speak at a combined National Automatic Control Conference—Control System Components Conference dinner meeting, Thursday, November 5, 7:30 p.m., Sheraton-Dallas Hotel.

WEDNESDAY, NOVEMBER 4

Session 1—General **10:00–12.00 a.m.**

Chairman: *J. E. Ward*, PGAC chairman, MIT
Welcoming Address: *J. Erik Jonsson*, chairman of the board of Texas Instruments, Inc., and past-president of Dallas Chamber of Commerce

Fundamental Theory of Automatic Linear Feedback Control Systems, by *I. M. Horowitz*, North American Aviation, Los Angeles, Calif.

General Approach to Control Theory Based on the Methods of Lyapunov, by *R. E. Kalman*, RIAS, Inc., Baltimore, Md., and *J. E. Bertram*, I.B.M. Research Center, Yorktown Heights, N.Y.

Impact of Information on Control. *H. Chestnut* and *W. Mikelson*, General Electric Co., Schenectady, N.Y.

Special Session—Control Problems of the Space Age **2:00–5:00 p.m.**

Chairman: *J. M. Salzer*, Ramo-Wooldridge, Los Angeles, Calif.

Controlled Propulsion, by *K. K. Dannenberg*, Jupiter Project Director, Army Ballistic Missile Agency

Attitude Control of Space Vehicles, by *C. R. Gates*, Chief of Guidance Systems Analysis, Jet Propulsion Lab.

Tracking and Path Control, by *R. C. Booton, Jr.*, Guidance and Navigation Dept., Space Technology Labs., Inc.

Control of the Human Environment, by *Paul Webb*, consultant.

THURSDAY, NOVEMBER 5 9:00–12:00 a.m.

Session 2—Nonlinear Control Theory

Chairman: F. W. Tatum, Electrical Engineering Dept., Southern Methodist University

Signal Stabilization of Self-Oscillating Systems by *R. Oldenburger*, Purdue Univ., and *T. Nakada*, Tokyo Inst. of Tech.

A Root Locus Method for the Analysis of Nonlinear Servomechanisms, by *M. J. Absug*, Douglas Aircraft Co., Inc., El Segundo, Calif.

Some Nonlinear Control Techniques Novel to Control Engineers Employed by a Biological Control System, *M. Clynes*, Rockland State Hospital, Orangeburg, N. Y.

On the Analysis of Bi-Stable Control Systems, *B. E. Amsler* and *R. E. Gorozdos*, Applied Physics Lab., the Johns Hopkins Univ., Silver Spring, Md.

Effect of Power Source Regulation on the Response of a Control-System Amplifier, *R. J. Kochenburger*, Univ. of Connecticut

Session "CSCC-1"—Magnetic Components—Transformers

Session "CSCC-2"—Instrumentation

THURSDAY, NOVEMBER 5 2:00–5:00 p.m.

Session 3—Automatic Control Devices and Systems

Chairman: *A. R. Teasdale*, Temco Aircraft Corp., Dallas, Texas

Pendulous Velocity Meter-Control Synthesis, by *S. G. Shutt*, Autonetics, Div. of North American Aviation, Inc., Downey, Calif.

The Analysis of Demodulating Compensating Network, by *G. J. Murphy* and *J. F. Egan*, Northwestern Univ.

Mathematical Models for Computer-Control Systems, by *T. M. Stout*, Thompson-Ramo-Wooldridge Products Co., Los Angeles, Calif.

Multiloop Temperature-Control System for Fluid Dynamics Facility with Long Transport Delays, by *G. J. Fiedler* and *J. J. Landy*, Sverdrup and Parcel Engineering Co., St. Louis, Mo.

Some Linear and Nonlinear Aspects of Hot Gas Servo Design, by *R. V. Halstenberg*, Convair, San Diego, Calif.

Session 4—Control System Synthesis and Optimization (Organized by ASME)

Chairman: *C. F. Taylor*, Daystrom, Inc., La Jolla, Cal.

A General Flow Graph Technique for the Solution of Multi-Loop Sampled Systems, by *R. Ash, W. H. Kim*, and *G. M. Kranc*, Columbia Univ.

Synthesis of Third Order Contactor Control Systems, by *Irmgard Flügge-Lotz*, Stanford Univ.

On After-End-Point Motions of General Discontinuous Control Systems and Their Stability, *P. Seibert*, RIAS, Inc., Baltimore, Md.

On the General Theory of Control Systems, by *R. E. Kalman*, RIAS, Inc., Baltimore, Md.

On Optimal Computer Control, by *J. E. Bertram* and *P. E. Sarachik*, I.B.M. Research Center, Yorktown Heights, N. Y.

The Second Method of Lyapunov in the Analysis and Optimization of Control Systems: Sampling Systems, by (presentation by title only) *R. E. Kalman*, RIAS, Inc., Baltimore, Md., and *J. E. Bertram*, I.B.M. Research Center, Yorktown Heights, N. Y.

Session "CSCC-3"—Magnetic Components—Amplifiers

FRIDAY, NOVEMBER 6 9:00–12:00 a.m.

Session 5—Automatic Flight Control

Adaptive Flight Control (ISA paper), by *O. H. Schuck*, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

Electronic Gain Control in Automatic Flight Control Systems, by *W. Henn* and *A. S. Robinson*, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

Electronic Memory in Automatic Flight-Control Systems, by *D. Blanvett* and *A. S. Robinson* Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

Pulse Controlled Integration in Automatic Flight Control Systems, by *A. S. Robinson*, Eclipse-Pioneer, Bendix Aviation Corp., Teterboro, N. J.

Reactor Wheel Attitude Control for Space Vehicles, by *R. W. Froelich* and *H. Patapoff*, Space Technology Lab., Inc., Los Angeles, Calif.

Session "CSCC-4"—Hydraulic Components

FRIDAY, NOVEMBER 6 2:00–5:00 p.m.

Session 6—Control System Design Techniques

Chairman: *J. H. Mulligan, Jr.*, Electrical Engineering Department, New York Univ.

D-Decomposition Analysis of Automatic Control Systems (ISA paper), by *R. W. Lanskron*, Martin Co., Orlando, Fla., and *T. J. Higgins*, Univ. of Wisconsin

Optimization of the Adaptive Function by the Z-Transform Method (AIEE paper), by *S. S. L. Chang*, New York Univ.

Application of Pole-zero Concepts to Design of Sampled Data Systems, by *D. P. Lindorff*, Univ. of Connecticut.

Synthesis of Feedback Systems with Specified Open-Loop and Closed-Loop Poles and Zeroes, by *W. E. Carpenter*, Space Technology Labs., Los Angeles, Calif.

Calculating Zeroes of Functions Arising in Various Control System Problems (AIEE paper), by W. R. Evans, Autonetics, Div. of North American Aviation, Downey, Cal.

Session 7—Random Processes in Control Systems

Chairman: *H. Freeman*, MIT

Random Sampling: Its Effect on Spectral Density, by *A. R. Bergen*, Univ. of California

A Procedure for Synthesizing Linear Time-Varying Shaping Filters for Generating Nonstationary Random Outputs (ISA paper), by *M. M. Sondhi* and *T. J. Higgins*, Univ. of Wisconsin

Spectral Characterization of Control System Nonlinearities, by *R. B. McGhee*, Hughes Aircraft Co., Culver City, Calif.

Techniques for the Optimum Synthesis of Multipole Control Systems with Random Processes as Inputs, by *C. T. Leondes* and *H. S. Hsieh*, Univ. of California (Los Angeles)

Predictor Relay Servos with Random Inputs, by *T. R. Benedict*, Cornell Aeronautical Labs., Buffalo, N. Y.

Session "CSCC-5"—Electromechanical Components

Request for Literature

The SEATO Graduate School of Engineering is being established in Bangkok, Thailand, under the direction of Colorado State University Research Foundation through a contract with International Co-operation Administration. A comprehensive reference library is planned to serve the staff and students, initially in the field of civil engineering and later in electrical engineering and mechanical engineering.

If you have, or know of anyone who has, engineering literature in the form of periodicals, books, manuals, microfilms, special reports, and the like, a contribution to this library would be valuable. Please write to: Dr. Maurice L. Albertson, Director, Colorado State University Research Foundation, Fort Collins, Colo.

ASME CODES AND STANDARDS WORKSHOP

Interpretations of 1955 Code for Pressure Piping

From time to time certain actions of the Sectional Committee B31 will be published for the information of interested parties. While these do not constitute formal revision of the Code, they may be utilized in specifications, or otherwise, as representing the considered opinions of the Committee.

Pending revision of the Code for Pressure Piping, ASA B31.1-1955, the Sectional Committee has recommended that ASME, as sponsor, publish selected interpretations so that industry may take immediate advantage of corresponding proposed revisions. Case 30 (reopened) is published herewith as interim actions of Sectional Committee B31 on the Code for Pressure Piping that will not constitute a part of the Code until formal action has been taken by the ASME and by the American Standards Association on a revision of the Code.

Case No. 30

Section 5 is excluded from the provisions of this case.

Drill Driver Revision

By Harry J. Moffat, Chairman, B5TC7

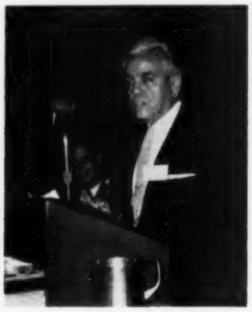
This revision approved by the Sectional Committee and in the process of publication will include the addition of 22 selected sizes of millimeter drills that were added to the recent revision of ASA B5.12-1958. The range of sizes also was revised to include sizes through 0.750 instead of 0.6875 as in the 1951 publication. It was requested that the sizes be listed by drill size and the decimal equivalent also, due to the increased use of the decimal dimension system.

Dimensions in the drawings and tables are defined. Wider circulation of American Standards makes it necessary that any technical information be made as clear as possible.

The Technical Committee would appreciate any comments or criticism that would promote the acceptance and use of this standard.

President Warren Speaks on New Horizons in Heat Transfer

President Warren: "Heat transfer is the limiting factor. . ."



Prof. C. H. Coogan, Jr., **center,** ASME's Vice-President of Region I, meets with Division Chairmen A. C. Mueller, **left,** and W. E. Hammond

Joint ASME-AIChE Heat Transfer Conference and Exhibit attended by 600

ASME President Glenn B. Warren, speaking at the banquet of the Joint ASME-AIChE Heat Transfer Conference in Storrs, Conn., said:

"You are in a growing and dynamic field of technology which has tremendous potentialities for growth and application to meet the expanding needs of this age of science and engineering. You are doing a fine job in laying the basic foundations to meet these needs, and you could hasten the reduction to practice in many areas by emphasis, not in place of the fundamentals but to supplement these on the application and design areas of this changing field of technology."

The conference, held Aug. 9–12, 1959, was the third National Heat Transfer Conference and Exhibit sponsored jointly by the ASME and AIChE Heat Transfer Divisions, and this time with the cooperation of ASME's Hartford Section and the University of Connecticut.

More than 550 engineers attended the Storrs meeting, and enough of them brought their wives to bring the total registration well above 600.

President Warren, departing from his prepared speech, voiced his concern that the best students in many cases are veering away from mechanical engineering and are ignoring the fact that mechanical engineering has wider application to the modern problems than any other discipline.

"In a post-World War II appraisal of our technological needs at General Electric," he said, "we came up with an understanding that our two greatest deficiencies existed in the heat-transfer and metallurgical areas . . . within a few years, the explosive needs of new technology demanded considerations of heat-transfer requirements that were a whole order of magnitude or more in advance of what we had all been doing.

"Even those problems became simple compared to the new ones involved in nuclear-power reactors. Here . . . the heat-transfer rates must be three to five times what they have been in the highest rated fossil-fuel boilers.

"If we look at the gas turbine, we find a host of new kinds of heat-transfer problems—turbine-wheel cooling, turbine bucket and nozzle cooling, combustion-chamber liner cooling, regeneration of exhaust heat.

"On the airplane gas turbine . . . we are cooling turbine wheels with 700 to 800 F air, and then we drive these planes so fast that cooling problems develop in the cockpit; and further, we must cool the lubricating oil by the fuel going to the turbine . . . with the rocket, we must handle oxidizers at many hundreds of degrees below zero, and combustion temperatures must be measured in the thousands.

"There are two new areas of technology that may make new and different demands on the science of heat transfer. One is the need for a low-cost means of producing fresh water from salt. I suspect that the multiple-effect evaporative process will have quite a wide application.

"The second has to do with the probable use of H-bombs in underground explosions to develop power and to drive oil and gas out of lean oil-bearing rocks and sand. These will mean new and altogether different concepts of heat transfer than any we have ever had before."

Connecticut industrialist, W. C. Beckley, who is a member of both the ASME and AIChE, served as toastmaster at the banquet. He introduced the presidents of both these founder societies.

Technical Papers. Between the two societies, 56 technical papers were sponsored and presented, plus two official panel sessions—plus a large impromptu session that lasted far into one evening. When heat-transfer engineers get together, it is hard to contain them within the limits of an official agenda.

The technical papers covered such a broad field that they were not easy to group. There were gas problems, liquid-metal problems, problems of ballistic missiles. W. E. Hammond, vice-president of Air Preheater Corporation and chairman of ASME's Heat Transfer Division, summarizing the conference, spoke especially of the studies on boiling.

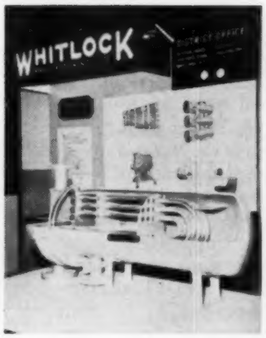
"We don't know enough about the boiling process," he said. "We're trying to understand the molecular phenomenon that goes on in boiling."

University in the Hills. Host to the Conference was the University of Connecticut which began in 1881 as the "Storrs Agricultural College." Their first curriculum in mechanical engineering was established in 1916, and the school awarded its first BS—in mechanical engineering—in 1920. Today, "U-Conn" has 1400 undergraduate and 400 graduate engineering students.

An open panel discussion in the United Nations Room

Sigmund Kopp, **left**, of Alco Products, and Myron Tribus, UCLA, active in ASME's Heat Transfer Division

Toastmaster W. C. Beekley, President of Whitlock Mfg. Company



Among the exhibition booths in the main lounge of the Student Union Building

Prof. C. H. Coogan, Jr., head of the University's Department of Mechanical Engineering, is also ASME's Vice-President of Region I, and served as General Conference Chairman. It was Professor Coogan who made the introductions at the first technical session, and who welcomed the Conference to Storrs and the University.

For the assembled mechanical and chemical engineers, there were tours of the Nuclear Division of Combustion Engineering, Inc.; to the Aircraft Nuclear-Engine Laboratory of Pratt & Whitney; to the Maxim Marine Test Station at Millstone Point.

The terrain—and the Committee—afforded a number of pleasant diversions. There was a picnic and two clambakes, and—for the ladies—trips to Old Sturbridge in Massachusetts, the Mystic Marine Museum, and the Nathan Hale Homestead. On the first evening, theatregoers saw a performance of "The Time of the Cuckoo."

The women's program (Mrs. W. E. Hilding in charge) encompassed the care and entertainment of the children who accompanied their parents to this summer conference. Thirty children were on hand, many of them preschool.

For them, the Conference offered a swimming pool and other entertainment, notably special movies for youngsters, covering such matters as the Three Bears, a circus story, and a story about a fox. The business of the three bears is as important to little kids as nucleate boiling is to certain other people.

Availability List—Heat Transfer Conference

The papers in this list are available in separate copy form until June 1, 1960. Please order only by paper number; otherwise the order will be returned. Copies of these papers may be obtained from the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Papers are priced at 40 cents each to members; 80 cents to nonmembers. Payment may be made by check, U. S. postage stamps, free coupons distributed annually to members, or coupons which may be purchased from the Society. Coupons, in lots of ten, are $3 to members; $6 to nonmembers.

59—HT-1 Laminar Transfer From Isothermal Spanwise Strips on a Flat Plate, by H. H. Sogin

59—HT-2 Measurement of the Thermal Conductivities of Gases at High Temperatures, by R. G. Vines

59—HT-3 The Influence of Free Stream Turbulence on the Local Heat Transfer From Cylinders, by R. A. Seban

59—HT-4 Radiant Interchange Within an Enclosure, by J. T. Bevans and R. V. Dunkle

59—HT-5 Heat Transfer From Yawed Cylinders in Rarefied-Air Flows, by L. V. Baldwin, V. A. Sandborn, and J. C. Laurence

59—HT-6 Conical Turbulent Boundary-Layer Experiments and a Correlation With Flat Plate Data, by W. S. Bradfield

59—HT-7 A Variable-Density Single-Fluid Model for Two-Phase Flow With Particular Reference to Steam-Water Flow, by S. G. Bankoff

59—HT-8 Radiation Fin Efficiency for One-Dimensional Heat Flow in a Circular Fin, by R. L. Chambers and E. V. Somers

59—HT-9 Spectral Characteristics of Fabrics From 1 to 23 Microns, by R. V. Dunkle, F. Ehrenburg, and J. T. Gier

59—HT-10 Pressure Drop and Heat Transfer in a Duct With Triangular Cross Section, by E. R. G. Eckert and T. F. Irvine, Jr.

59—HT-11 Freezing of a Growing Liquid Column, by G. Horvay

59—HT-12 Heat Transfer in Flow Through Rotating Ducts, by C. Y. Kuo, H. T. Iida, J. H. Taylor, and F. Kreith

59—HT-13 Heat Transfer to Fully Developed Laminar Flow in a Circular Tube With Arbitrary Circumferential Heat Flux, by W. C. Reynolds

59—HT-14 Magnetohydrodynamic Effects Upon Heat Transfer for Laminar Flow Across a Flat Plate, by R. D. Cess

59—HT-15 Steam Slip—Theoretical Prediction From Momentum Model, by S. Levy

59—HT-16 Unsteady Turbulent Heat Transfer in Tubes, by E. M. Sparrow and R. Siegel

59—HT-17 Radiation Fin Effectiveness, by J. G. Bartas and W. H. Sellers

59—HT-18 Aspects of Local Boiling Effects on Density and Pressure Drop, by C. P. Costello

59—HT-19 Thermodynamic Properties of Helium at Low Temperatures and High Pressures, by D. B. Mann and R. B. Stewart

59—HT-20 Effect of Thermocouple Cavity on Heat-Sink Temperature, by J. V. Beck and H. Hurwicz

59—HT-21 Refractory Metal Thermocouples, by J. C. Lachman

59—HT-22 Transient One-Dimensional Heat-Conduction Analysis for Heterogeneous Structures Including an Ablating Surface, by M. L. Miller

59—HT-23 Conductive Heat Transfer in a Reentry Body—Analysis of Computational Methods and Their Reliability, by H. Hurwicz and M. S. Klamkin

59—HT-24 Experimental Determination of the Turbulent Heat-Transfer Rate Distribution Along a Slender Blunt-Nosed Body From Shock Tube Tests, by E. Offenhartz and H. Weisblatt

59—HT-25 Forced Circulation Uniform Flux Burnout Studies for High-Pressure Water, by S. J. Green, B. W. Le Tourneau, and M. Troy

59—HT-26 One-Dimensional Quasilinear Heat Flow With Boundary Conditions Periodic in Time, by D. N. Roy and J. S. Thompson

59—HT-27 The Effect of Transverse Vibrations on the Heat-Transfer Rate From a Heated Vertical Plate in Free Convection, by A. J. Shine

59—HT-28 Improved Lumped Parameter Method for Transient Heat-Conduction Calculations, by H. G. Elrod, Jr.

Durand Centennial Conference Held in California

To HONOR the 100th anniversary of the birth of Dr. William Frederick Durand, a great maritime, mechanical, and aeronautical engineer who was head of the Department of Mechanical Engineering of Stanford University from 1904 to 1924, and died last summer at the age of 99, Stanford University held a Durand Centennial Conference on Aeronautics and Astronautics from August 5 to 8, 1959. The Conference was sponsored by the Air Force Office of Scientific Research, the Office of Naval Research, the Office of Ordnance Research, the National Science Foundation, the Institute of the Aeronautical Sciences, and The American Society of Mechanical Engineers. Nineteen papers on aeronautics and astronautics were presented by leading authorities from the United States, Canada, and Europe and more than 600 persons attended the meetings.

The chairman of the opening session was Donald L. Putt, Lieut. General, U.S. Air Force (Ret.), President of United Research Corporation of Menlo Park. The participants in the Conference were greeted in the name of Stanford University by David Packard, Charimàn of the Board of Trustees of Stanford University. The Conference was officially opened by Colonel Raymond A. Gilbert, Deputy of Sciences, Air Force Office of Scientific Research.

The first paper of the opening session was an evaluation of Durand's contributions to aeronautics by Hugh L. Dryden, Deputy Administrator of the National Aeronautics and Space Administration. The second paper was presented by Sir Geoffrey Taylor, one of the world's leading experts in applied mechanics and the physics of metals and former professor at Cambridge University, England. He talked about "Similarity Solutions of Hydrodynamic Problems." This presentation was followed by the dedication of the William Frederick Durand Laboratory of the Department of Aeronautical Engineering of Stanford University. The dedication address was given by Dr. Theodore von Karman, Chairman of the Advisory Group for Aeronautical Research and Development of NATO, Paris, France. The new name plate of the laboratory was unveiled by Mrs. Georgia Durand Brandon, a niece of Dr. Durand.

Structural problems of hypersonic airplanes, missiles and spacecraft were discussed by Richard R. Heldenfels, Chief of Structural Research of the National Aeronautics and Space Administrations' Langley Research Center; Luigi Broglio, Head of the Institute for Aeronautical Construction of the University of Rome in Italy; W. Thielemann, an outstanding research man from the DVL, the German equivalent of our NASA; Jan Hult of the Royal Institute of Technology, Stockholm, Sweden; J. F. Besseling of Stanford University; and Wilfred H. Dukes, Chief of Structures, Dyna-Soar Department, Space Flight and Missiles, Bell Aircraft Corporation.

New solution of gas dynamic and hypersonic aerodynamic problems were presented by Gordon N. Patterson, Director, Institute of Aerophysics, University of Toronto; Hans W. Liepmann of the California Institute of Technology; Leslie S. G. Kovásznay of The Johns Hopkins University; Hugues de l'Estoile of the French Air Force in Paris, France; and Antonio Ferri, Head of the Department of Aeronautical Engineering of the Polytechnic Institute of Brooklyn. The astronautical program contained a paper by Von R. Eshleman of Stanford University on "Radar Astronomy"; two presentations on magnetogasdynamics and plasmadynamics by Professors J. M. Burgers of the University of Maryland, and Francis Clauser of The Johns Hopkins University; a paper on "Precision Orbits and Observation Reduction" by Samuel Herrick of the University of California at Los Angeles. The motion and ablation of meteoric bodies were analyzed by H. Julian Allen, Chief, High-Speed Research Division, National Aeronautics and Space Administration. The last paper of the program was a general review of the past, present, and future of astronautics by one of the early adherents of space flight and also one of the first record men in soaring flying in the early 1920's, W. B. Klemperer of Douglas.

The success of the meeting was enhanced by the outstanding group of chairmen of the technical sessions. In addition to General Putt, who took care of the opening session, there were three directors of research of major airplane manufacturing companies on the list. They were George S. Schairer, vice-president of Boeing Airplane Company, Dr. Albert E. Lombard, Jr., director of Research, McDonnell Aircraft Corp., and Charles L. Critchfield, director of Scientific Research, Convair-General Dynamics Corp. The remaining three sessions were chaired by Prof. S. A. Schaaf of the University of California, Richard L. Schleicher, chief structures engineer of North American Aviation, and Dr. M. U. Clauser, director, Aeronautical Research Laboratory, Space Technology Laboratories.

On Thursday evening, August 6, the banquet of the Conference was held at Adobe Creek Lodge, approximately ten miles south of Stanford University. It was attended by about 250 participants of the Conference and their wives, who listened with great interest to an after-dinner talk by Willis M. Harwkins, Jr., assistant general manager of the Lockheed Missiles and Space Division. Mr. Hawkins, in an informative and witty talk, expressed his fervent belief in man's ability to reach the stars soon. Greetings were brought to the Conference by William Littlewood, vice-president, Research and Development Department, Administrative Division of American Airlines, who is this year's president of the Institute of the Aeronautical Sciences; by Admiral L. V. Honsinger, Commandant of the Mare Island Naval Shipyard of the U. S. Navy in San Francisco Bay, who as a council member represented the Society of Naval Architects and Marine Engineers; and by V. F. Estcourt, General Superintendent of Steam Generation, Pacific Gas and Electric Company, San Francisco, who was a personal representative of the president of The American Society of Mechanical Engineers. It is of interest to note that during his lifetime, Durand had spent 40 years as a member of the council of the Society of Naval Architects and Marine Engineers, and for one year was president of The American Society of Mechanical Engineers. The toastmaster of the banquet was Nicholas J. Hoff, Head of the Department of Aeronautical Engineering of Stanford University.

They Came to Honor Durand. **Left to right.** General Putt; Dr. Hoff; Ernest Robischon, ISA Western Regional Manager; Admiral Bennett, chief of Naval Research, Washington, D. C.; Captain McLaughlin, Office of Naval Research, San Francisco, Calif.; and Smith J. DeFrance, director, Ames Research Center, NASA, Moffett Field, Calif.

ASME COMING EVENTS

October 20–22

ASME-ASLE Lubrication Conference, Hotel Sheraton-McAlpin, New York, N. Y.

October 27–29

ASME-AIME Fuels Conference, Netherland Hilton Hotel, Cincinnati, Ohio

November 4–6

ASME-IRE-AIEE-ISA National Automatic Control Conference, Sheraton Hotel, Dallas, Texas

November 8–13

ASME-ASTM-ACS International Rubber Conference, Shoreham and Park Plaza Hotels, Washington, D. C.

November 29–December 4

ASME Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

March 6–9, 1960

ASME Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston, Texas

March 14–15, 1960

ASME Lubrication Symposium, Engineering Societies Building, New York, N. Y.

March 31–April 9, 1960

ASME Textile Engineering Conference, North Carolina State College, Raleigh, N. C.

April 4–8, 1960

Nuclear Congress and Exhibit, Coliseum, New York, N. Y.

April 13–14, 1960

ASME-AIEE Railroad Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

April 21–22, 1960

ASME-SAM Management Conference, Statler-Hilton Hotel, New York, N. Y.

April 25–26, 1960

ASME Maintenance and Plant Engineering Conference, Chase–Park Plaza Hotels, St. Louis, Mo.

April 25–29, 1960

ASME Metals Engineering Division-AWS Conference, Hotel Biltmore, Los Angeles, Calif.

May 17–19, 1960

ASME Production Engineering Conference, Hotel Schroeder, Milwaukee, Wis.

May 22–26, 1960

ASME Oil and Gas Power Conference and Exhibit, Muehlebach Hotel, Kansas City, Mo.

May 23–26, 1960

ASME Design Engineering Conference and Show, Statler Hilton Hotel, New York, N. Y.

June 5–10, 1960

ASME Semi-Annual Meeting and Aviation Conference, Statler Hilton Hotel, Dallas, Texas.

June 15–17

ASME Applied Mechanics Conference, The Pennsylvania State University, University Park, Pa.

(For Meetings of Other Societies see page 114)

Note: Members wishing to prepare a paper for presentation at ASME National meetings or divisional conferences should secure a copy of Manual MS-4, "An ASME Paper," by writing to the ASME Order Department, 29 West 39th Street, New York 18, N. Y., for which there is no charge providing you state that you are a member of ASME.

Student Members and Advisers Meet at Twelve Regional Conferences

1300 Meet During Spring; 60 Students Present Prize-Winning Papers

Student Members of The American Society of Mechanical Engineers and their Faculty Advisers—1300 in all—met during the Spring of 1959 at twelve regional Student Conferences throughout the country.

Programs at these conferences mirrored in miniature those of the Society's annual meeting. There were technical sessions, visits to industrial sites, banquets at which distinguished engineers addressed the groups, and informal gatherings. Prizes, given for the largest regional attendance, to schools traveling the greatest number of man-miles, and to participants in the papers contest, were an additional feature of the meetings.

For many the conferences afforded a first opportunity to observe the working of their professional society outside their own Student Section.

The conferences are designed to permit the exchange of technical information; to acquaint the students with the operational aspects of the Society's activities; and to allow the students to meet their contemporaries and compare ideas on Student Section operation. Through the conferences, students learn that for the Society to be helpful to them they must participate in its activities.

Paper Contest. Of the 133 technical papers presented at the conferences, 60 were awarded prizes. Subjects ranged from "Dancing Ice Cubes" to "Boundary-Layer Control by Suction Through Distributed Perforations." Papers were judged on the basis of content, organization, delivery, and effectiveness; and consideration also was given to the amount of discussion evoked by a presentation. The caliber of all the papers was high, making selection of prize winners a difficult task. Experience gained by the young engineers who presented papers will prove invaluable when they enter their chosen fields.

The Business of Student Sections. At Faculty Advisers meetings held during each of the conferences, advisers and students alike had occasion to discuss the various details of business connected with Student Section operations. The Student Sections relation to its Local Section ASME and to Headquarters came up for discussion at a number of such meetings.

On the campus, the chief concern is interesting the members and continuing to attract them to meetings. A number of suggestions for heightening interest in Student Section meetings were offered.

One school has had notable success with an "Engineering Theater." The students arrange to show films made available by industry, government agencies, and other sources. These films, often describing new engineering developments, are well attended.

With the co-operation of the local ASME Section, a number of other schools have sponsored forum-type meetings. At these meetings, industry representatives explain what industry expects of the young engineer, the kinds of engineering work available, and how to prepare for and what to do during an employment interview—all questions of deep concern to the student engineer.

Other Sections have shown their interest in the Student Sections by providing programs and speakers for meetings, inviting student groups to their meetings, and, in some cases, allowing the Student Chairmen to sit in on their Executive Committee meetings.

In the Student Sections' relation with Headquarters, one important factor was noted at each of the meetings—and that is clerical in nature. Students are urged when they are promoted from Student Member to Associate Member to notify the Society of their change of address. Last year, 35 per cent of the transfers addresses were not recorded.

1959 ASME Regional Student Conference Reports

Region I, New England, Worcester Polytechnic Institute, Worcester, Mass., April 17–18, 1959

Attendance: 174 — Papers Presented: 9

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Alan K. Karplus	Dancing Ice Cubes	Tufts University
Second	Chester F. Jacobson	A Triangular Panel Portable Bridge	Worcester Polytechnic Institute
Third	Lee S. Langston	Heating Effects of High Altitude	University of Connecticut
Fourth	W. John Brunt	Fundamentals and Processing of Metallic Laminates	University of Vermont
Old Guard	Robert A. Gussman	Operation of a Continuous High-Temperature Slag-Wool Filter	Northeastern University

Region II, Eastern, Stevens Institute of Technology, Hoboken, N. J., April 11, 1959

Attendance: 40 — Papers Presented: 5

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Howard Beroff	Some Work in Medical Engineering	Polytechnic Institute of Brooklyn, Day Division
Second	Ronald B. Laurence	Flow Characteristics of Solenoid Valves	Stevens Institute of Technology
Third	Martin N. Kann	Design of a Paper Sorter and Tallying Device	Newark College of Engineering
Fourth	Fred M. Michelsohn	Split-Match-Plates in Foundry Practice	New York University, Day Division
Old Guard	Edward Latin	New Ramjet Adaptation to an Aircraft Engine	City College of New York

Region III, Alleghenies, Lafayette College, Easton, Pa., April 17–18, 1959

Attendance: 132 — Papers Presented: 15

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	James F. Malley	Forced Heat Convection With Incompressible Liquids in Horizontal Pipes	Lafayette College
Second	James M. Woodward	An Engineering Approach to a Study of Psychomotility	Villanova University
Third	Charles R. Gellerly	Automatic Transmissions	Drexel Institute of Technology
Fourth	Harry A. Defarrari	Ground-Effect Machine	The Catholic University of America
Old Guard	James A. Yannes	Human Engineering	Union College

Region IV, Southern, University of Florida, Gainesville, Fla., April 18–19, 1959

Attendance: 134 — Papers Presented: 13

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Daniel M. Germany	Some Considerations in Orbiting Satellites	Mississippi State University
Second	Richard P. Braden	Dual-Breaker Point Distributor for Automotive Engines	Georgia Institute of Technology
Third	H. Thomas Robins	Creativity in Engineering	Duke University
Fourth	Edgar H. Callaway	Instrumentation for Automatic Feed-Water Control	University of Florida
Old Guard	Maxcey C. Rivkin	Fluid Mechanics of the Human Circulatory System	University of South Carolina

Region V, Mid-Western, University of Michigan, Ann Arbor, Mich., April 17–18, 1959

Attendance: 131 — Papers Presented: 8

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Jariel D. Dainow	Engineers' Unions With Respect to Professionalism	Ohio State University
Second	Beynon J. Lahr, Jr.	Movements Generated by Eccentric Sprockets	University of Akron
Third	James A. Thacker	Analytical Performance Study of a Compound Diesel	University of Cincinnati
Fourth	Eugene G. Lauro	Rubber Processing	The Ohio University
Old Guard	Robert J. Gordon	Instrument Flying	Carnegie Institute of Technology

Region VI, Northern Tier, South Dakota State College, Brookings, S. Dak., May 1–2, 1959

Attendance: 139 — Papers Presented: 9

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Lee C. Pittenger	Magnetohydrodynamics	Marquette University
Second	Daniel D. Joseph	Heat Conductor in an Infinite Rectangular Coil	Illinois Institute of Technology
Third	Edward D. Enright	The Economic Feasibility of Nuclear Power	South Dakota School of Mines
Fourth	Clemens J. Heltemes, Jr.	And Let There Be Light	North Dakota State College
Old Guard	Hartmut E. Schierling	Education in Germany	South Dakota State College

Region VI, Southern Tier, Purdue University, West Lafayette, Ind., April 3–4, 1959

Attendance: 116 — Papers Presented: 10

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Paul E. Patton	The Impedance Method of Vibrational Analysis, A Key to Survival	University of Kentucky
Second	Paul Schlender, Jr.	Project Plowshare	Purdue University
Third	John T. Gerhardt	Is There a Better Way to Make Electricity?	University of Louisville
Fourth	Joel E. Haggard	Hesitancy Born of a Hazard	University of Notre Dame
Old Guard	Sidney J. Green	Methods of Determining Vibrations With Strain Gages	Missouri School of Mines & Metallurgy

Region VII, Pacific Northwest, Oregon State College, Corvallis, Ore., April 30–May 1, 1959

Attendance: 95 — Papers Presented: 10

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Raymond T. Jessen	Geo-Thermo Power Development in the United States	State College of Washington
Second	Rajeshwar K. Malhotra	Plasma and Its Applications	Oregon State College
Third	Maurice Kurtz	Failure Analysis of Ammonia Compressor-Valve Rings	Oregon State College
Fourth	Donald G. Strang	Free-Piston Engines	University of British Columbia
Old Guard	John L. Irvine	Curved Channel Flow	University of British Columbia

Region VII, Pacific Southwest, University of Southern California, Los Angeles, Calif., May 8–9, 1959

Attendance: 69 — Papers Presented: 11

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	John F. Cepollina	Theory and Operation of a Hot Water Rocket	University of Santa Clara
Second	Leo O. Reed	Condenser-Tube Corrosion in Steam-Power Plants	University of Southern California
Third	Edward E. Betts	Flow Simulator of Perfect Fluid-Flow Theory	University of Arizona
Fourth	Sidney H. Smith	Heat Transfer to a Surface Manifesting Active Properties	University of Utah
Old Guard	Donald H. Mann	Cycloid Speed Reducer	University of Southern California

Region VIII, Northern Tier, University of Arkansas, Fayetteville, Ark., April 27–28, 1959

Attendance: 128 — Papers Presented: 12

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Joseph W. McKinley	Noise Level of Cooling Tower Fans	University of Kansas
Second	William R. Mahieu	Effect of Fiber Length and Orientation on the Behavior of Glass-Resin Composites	Kansas State University
Third	Marvin Stacken	Electric Heating	University of Kansas
Fourth	Larry C. Ball	Photographic Determination of Radiation Shape Factors	Kansas State University
Old Guard	Robert C. Poe	The Use of Resistive Strain Gages in Engineering Measurement	University of Oklahoma

Region VIII, Southern Tier, Louisiana State University, Baton Rouge, La., April 17–18, 1959

Attendance: 135 — Papers Presented: 20

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	James S. Kishi	Boundary-Layer Control by Suction Through Distributed Perforations	University of Texas
Second	Lado Muhlstein	Performance Characteristics of a Tesla Turbine	A&M College of Texas
Third	W. B. Jones	Aerothermodynamic Heating Coefficients	Texas Technological College
Fourth	Leon O. Billig	Gas-Lubricated Bearings	University of Houston
Old Guard	Frost E. Gardner	Operation, Construction, and Practicability of a Linear-Mass Flow Meter Employing a Rotor and Divided Flow	A&M College of Texas

Region VIII, Rocky Mountain Tier, University of Wyoming, Laramie, Wyo., April 10–11, 1959

Attendance: 75 — Papers Presented: 11

PRIZE	RECIPIENT	TITLE OF PAPER	COLLEGE
First	Alan E. J. Branigan	Vibrating Strength Into Metal	University of Colorado
Second	Barton R. Dwight	Three-Dimensional Cams	Colorado State University
Third	Thomas K. McKinley	Nuclear Reactors, Controls, and Safety	University of New Mexico
Forth	Edward L. Yellin	Industrial Safety	Colorado State University
Old Guard	Frederic A. Silva, Jr.	Inflation of Tires	University of Denver

Other Prizes Presented at the Regional Student Conferences for 1959

1 Two prizes of $25 and $15 were awarded at each Conference to the Student Section having the largest and next largest of Student Members attending.

2 Each Conference presents a Man-Mile Trophy to the Student Section who has traveled the greatest number of miles to the conference. Winners are listed below:

Region	$25	$15	Man-Mile Trophy
I	University of Rhode Island	Northeastern University	Northeastern University
II	Rutgers University	City College of New York Newark College of Engineering	
III	Howard University	University of Delaware Union College	Howard University
IV	University of South Carolina	Virginia Polytechnic Institute	Virginia Polytechnic Institute
V	Ohio Northern University	University of Dayton	University of Dayton
VI, Northern Tier	University of North Dakota	Iowa State University	University of North Dakota
VI, Southern Tier	Missouri School of Mines & Metallurgy	University of Kentucky	Missouri School of Mines & Metallurgy
VII, Pacific Northwest			State College of Washington
VII, Pacific Southwest	University of Utah	University of California	
VIII, Northern Tier	University of Oklahoma	University of Nebraska	University of Nebraska
VIII, Southern Tier	Southwestern Louisiana Institute	University of Houston	
VIII, Rocky Mountain Tier	University of Denver	Colorado State University	New Mexico State University

Conducted for the National Junior Committee

A. S. GOLDSTEIN[1]

JUNIOR FORUM

ASME Awards for Young Engineers

By Ernest T. Selig[2]

EACH year ASME bestows a number of honors and awards on members of the engineering profession in recognition for their distinguished service or for their outstanding contributions to engineering literature. Of these, several are specifically designated for the younger members of the profession. They are described in this article in order to focus particular attention on them apart from the other awards of the Society and, thereby, to encourage participation.

In the category of honors for distinguished service is the *Pi Tau Sigma Gold Medal Award*. Established in 1938 by Pi Tau Sigma, it is given annually to a young engineer for outstanding achievement in mechanical engineering within ten years after graduation. The award consists of a gold medal and a monetary supplement to cover expenses in attending the ASME meeting at which the award is to be given. Any man who on July 1 of each year has been graduated not more than ten years from the regular mechanical-engineering course of a recognized American college or university is eligible for this recognition. Achievement may be in any field or fields, including industrial, educational, political, research, civic, and artistic. The candidates' achievements are examined for an application of basic engineering methods or principles, but cultural development is also taken into consideration.

Pi Tau Sigma administers the funds for the award and by March 1 of each year requests nominations from the various Sections of ASME. Pi Tau Sigma then selects ten candidates for the award and submits them to the ASME Board of Honors. The Board, in turn, selects the recipient subject to the approval of the Council. The award is usually made at the ASME Annual Meeting.

In the category of outstanding contributions to engineering literature, there are several awards. One is the *Junior Award*. Established in 1914 by Henry Hess, Vice-President and Mem. ASME, this award is given for the best technical paper by an Associate Member of the Society. The award consists of an engrossed certificate and $50. To be eligible, original technical papers must have been presented before ASME and submitted for publication during the calendar year prior to the year of award by an Associate Member of the Society who is not more than 30 years of age at the time the paper was submitted. Joint authorship is permitted provided that all authors meet the qualifications. The paper must not have been made public previously or contributed to any other society, in whole or in part, and must make a distinct contribution to the literature of mechanical engineering. Nominations may be made through any Section of ASME or directly to the Medals Committee of ASME; they must be made by March 1 of each year, accompanied by eleven copies of the paper.

Another award for contributions to engineering literature is the *Spirit of St. Louis Junior Award*. Established in 1938 by the General Committee for the 1935 aeronautical meeting in St. Louis, Mo., this award is given for the best paper on an aeronautical engineering subject presented at an ASME meeting during the prior three-year period. To be eligible, this paper must have been prepared by a single author who is an Associate Member of ASME not more than 30 years of age at the time the paper was submitted to the Society. The award is made every three years and consists of an engrossed certificate and $50. Nominations are made in the same way as for the Junior Award.

The latest of the literature awards for young engineers is the *Arthur L. Williston Medal Award*. It was established in 1954 by Arthur L. Williston, Mem. ASME, to be awarded to the student or junior engineer for the best paper which sets forth ideas supported by appropriate argument, regarding changes of curriculums, and variations of procedures within the prescribed courses of study or in the extra curriculum area of his college that will tend to stimulate increased interest in civic activities for the benefit of society. Any undergraduate student in the junior or senior class in a course of mechanical engineering or a junior engineer who has had professional experience and who has received a baccalaureate degree within two years prior to the date of the award is eligible. Those who wish to compete for the award must prepare a 2000 to 5000-word paper in typewritten form and bound, and present it to the secretary of ASME prior to May

[1] Engineering writer, General Electric Advanced Electronics Center at Cornell University, Ithaca, N. Y. Assoc. Mem. ASME.

[2] Assistant research engineer, Armour Research Foundation, Chicago, Ill. Assoc. Mem. ASME.

How Well Do You Know Your Society?

SO THAT the members of ASME may know their Society, attention is called to the list of Manuals and Annuals available upon request from the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Unless otherwise noted, all the items in the list will be sent without charge, one copy of each per member.

AC 2	Annual Report of ASME Research
AC 10	Personnel of Council, Boards, and Committees
AM 1	Membership List—Alphabetical and Geographical (Biennial—odd-numbered years)
AM 3	Catalog of Publications (also included in "Mechanical Catalog")
AM 4	Members List—Listed by Companies (Biennial—even-numbered years, $2 each)
AM 5	Indexes to ASME Papers and Publications
MM 1	Certificate of Incorporation, Constitution, By-laws, and Rules
MS 4	An ASME Paper (50 cents to nonmembers)
MS 61	Citizenship and Participation in Public Affairs

1. The award consists of an engrossed certificate, a bronze medal, and a cash stipend which this year is $200.

There are also several ASME awards open to competition among Student Members of the Society. One such award, the *Charles T. Main Award*, is presented for the best paper written by a Student Member within the general subject of the influence of the engineering profession upon public life. Each year the Board on Honors selects the specific topic to be treated and announces it to the Student Sections on October 1. An undergraduate student wishing to compete for this award must submit his paper by May 15 (30 days after graduation for February graduates) to the vice-president of the Region in which the Student Section is located. The vice-president will select the best paper submitted to him and present it to the secretary of ASME as a nomination for the award. The award consists of an engrossed certificate and $150.

The Undergraduate and Postgraduate Student Awards are awarded for the best papers of any length on any subject submitted, respectively, by undergraduate and postgraduate Student Members of ASME. Each paper must be the original work of a single author and must not have been presented previously to, or published in part or in whole, by any society or technical publication other than ASME. The same procedure for submission and nomination is followed as for the Charles T. Main Award. The award consists of an engrossed certificate and $25.

The *Old Guard Prize* is awarded annually to the winner of the national contest of Student Members who have won the first prize at each of the 12 ASME Regional Student Conferences. Each participant must enter the competition held by his ASME Student Section and be selected to represent the Student Section at the Regional Student Conference. The winner of the first prize at each of the 12 Regional Conferences then attends the national contest at the Semi-Annual Meeting of the Society and re-presents his paper in competition for the Old Guard Prize. At the conclusion of his presentation, each contestant must submit his manuscript to the judges for review. The award consists of an engrossed certificate and $150. The contestants are also assisted financially to attend the Semi-Annual Meeting.

It is the intent of ASME in providing these particular awards that outstanding contributions of young engineers, whether by service or by literature, be recognized in order to inspire and encourage them to make even greater contributions to their profession. The Society invites its members who know of candidates eligible for the awards requiring nominations to take the appropriate action. For those awards where direct competition is called for, participation should be encouraged.

1960 Mechanical Catalog Ready for Distribution

COMMENCING October 1, copies of the 1960 Mechanical Catalog will be mailed to those members of The American Society of Mechanical Engineers who have already requested the new edition.

Designed as an aid in specifying and buying functions, it contains more than 40,000 listings, 6000 products of 3500 manufacturers, plus more than 250 pages of descriptive advertising matter of importance to the engineer in industry.

Since 1912, the Mechanical Catalog has been an invaluable reference for engineers in industry. Constant editing of listings, industry-inspired phraseology revisions, and a continuing flow of suggestions from industry have helped make the catalog the most influential of its kind.

One important feature of the 1960 edition is the 20-page descriptive listing of all ASME publications, which enables engineers to check quickly their requirements for the latest standards and codes as well as other special data.

Copies of the 1960 Mechanical Catalog are still available to ASME members upon written request addressed to R. Hoffman, Mechanical Catalog Manager, 29 West 39th Street, New York 18, N. Y.

ENGINEERING SOCIETIES PERSONNEL SERVICE, INC [Agency]

THESE items are listings of the Engineering Societies Personnel Service, Inc. This Service, which co-operates with the national societies of Civil, Electrical, Mechanical, and Mining, Metallurgical, and Petroleum Engineers, is available to all engineers, members or nonmembers, and is run on a nonprofit basis.

If you are interested in any of these listings, and are not registered, you may apply by letter or résumé and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5 per cent of the first year's salary if a nonmember, or 4 per cent if a member. Also, that you will agree to sign our placement-fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

NEW YORK	CHICAGO	SAN FRANCISO
8 West 40 St.	29 East Madison St.	57 Post St.

Men Available[1]

New York Office

Plant Engineer, graduate electrical, registered PE in five states; 48; knowledge and 20 years' experience in plant and construction engineering, electrical, mechanical, industrial, and construction. Experience includes management responsibilities and labor relations with union-contract negotiations. Effectively instituted production and preventive maintenance programs with cost-control methods and procedures. Location optional. Me-750.

Mechanical Engineer, BSME; 33; ten years' design and construction experience in process industries. Résumé on request. Prefers South. Me-751.

Mechanical Engineer, registered PE, master's degree, matriculating towards law degree; 36; 10 years' experience in power engineering. Present position project engineer. Seeks managerial position with growing company anywhere in U. S. Me-752.

Manager of Engineering, BS; 41; ten years' experience in design of chemical equipment and cryogenics; seven years engineering management as chief engineer and engineering manager. Prefers East. Me-753.

[1] All men listed hold some form of ASME membership.

Project Engineer, Machine Design, BSME 40; nine years as project engineer on heavy production machinery for all industries. Supervised projects from estimating to manufacture. Five years design; packaging machines, paper-making machines, industrial dryers, and gear units. Prefers Delaware Valley area. Me-754.

Mechanical Power-Plant Design and Project Engineer, PE; 40; 15 years' industrial and public, utility power-plant-engineering experience. Presently employed. East or South. Me-755.

Executive Engineer, BASc-ME (Toronto); 31; PE (Ont.). Broad experience; designer machine elements, consulting engineers' field supervisor, and resident engineer; owner's heavy construction project manager; assistant division manager—operation and maintenance of hydro-thermoelectric plants. Seeks challenging position as engineering-management executive on foreign service requiring initiative, organizational and administrative ability, facility with foreign languages. Present location Latin America. $13,000. Me-757.

Engineer, Manufacturing Administration, BME; 33; PE, ten years' manufacturing and design experience in metal fabrication including direct plant supervision, plant layout, and plant engineering. Prefers Northeast. Me-758.

Chicago Office

Research Engineer, BSME; 33; six years research and development; two years self-employed consulting engineer and boat (inboard) design and manufacture. Specialties: Machine design and stress analysis. Prefers Midwest or South. Me-980-Chicago.

Chief or Plant Engineer, BE, BSChE; PE; 41 18 years in supervision of design, installation; construction, start-up, plant engineering and maintenance of utility, chemical, and atomic processing plants including complete administrative and technical responsibility for multimillion dollar installations. Location immaterial. Me-981-Chicago.

General Manager, BME; 38; ran own company about one year and three months. Superintendent of construction and chief engineer, a total of seven years. Prefers South, Southwest, or West. Me-982-Chicago.

Engineer, BSME; 33; seven years natural gas utility, gas-measurement engineer, also design of high-pressure piping, pressure, and flow regulation. Two years industrial production; one year plant engineering with chemical plant. Prefers South or Midwest. Me-983-Chicago.

Machine Designer, three and one half years mechanical engineering; 34; 11 years' machines and structural frames; automotive material handling and parking units; machine tools, cranes, hoists, logging and sawmill equipment, stress analyst, design estimator. $9000. Prefers East or Midwest. Me-988-Chicago.

San Francisco Office

Junior Mechanical Engineer—Machine Elements: ME, 22. Two years' academic experience in machine design and unlimited interest in this field. $450. Prefers San Francisco Bay area. Home: San Francisco. (SM)-663.

Sales Manager—Industrial Controls: ME, 51, 28 years' experience in sales and engineering on industrial controls. $600 plus. Prefers San Francisco Bay area. Home: Calif. S(M)-623.

Plant Manager—Wood, Metal Products: ME, 44, 12 years manager, production control, personnel, inventory, maintenance for wood-products companies. Two years design plant layouts, purchase equipment, installation for telephone-equipment manufacturer. Two years methods engineering, time study, production for steel company. $15,000. Prefers San Francisco, Los Angeles. Home: Ill. S(M)-579.

Production Superintendent—Manufacturing: ME, 32, ten years' diversified experience in rubber industry. Last three years production superintendent extrusion and splicing operations medium-sized company. Experience developing new products, manufacturing methods, plant layout, cost and quality control. Prefers small, medium-sized manufacturing plant, any type. $700. Prefers San Francisco Bay area. Home: Calif. S(M)-541.

Plant Engineer, Production—Aircraft, Metal Products: ME, 42. Calif. ME License, 11 years supervising mechanical, electrical, civil, plant layout, facilities, production methods for aircraft manufacturer. Two and one half years plant layout, tool, schedule, purchase, customer relations on metal stamping and products assembly. Ten months physical test mechanical rubber goods. $14,000. Prefers Southern Calif. Home: Calif. S(M)-1733.

Petroleum, Lubrication Engineer—Oil, Fuel Development, Construction: ME, 28, two and one half years' experience assisting on plans, cost estimates, supervising civil, mechanical facilities for oil development. Three years fuel handling, supervising, maintenance-equipment instruction, and installation for Marine Corps. One and one half year lab assistant fuels and lubrication tests and experiments for university. $600 plus. Prefers overseas. Home: Calif. S(M)-700.

Designer, Construction—Steel Mills, Furnaces: ME (Scotland), 45, 23 years charge sales, engineering, design, contracts, estimates for steel-mill construction, furnaces, cranes. Two and one half years industrial engineer, methods, time study, design of plant and tools on box manufacturing. One and one half years civil, mechanical, electrical maintenance on bronze-casting and forgings plant. $15,000. Prefers West Coast. Home: Canada. S(M)-1629.

Designer, Draftsman—Air-Conditioning, Plumbing: 49. Many years' experience drafting, design of air conditioning, ventilation, heating, plumbing on industrial, commercial buildings, power plants; for architects, engineers, construction companies. $600. Prefers San Francisco Home: San Francisco. S(M)-454.

Design, Develop, Test Engineer—Mechanical: ME, 37, Ten and one half years design, develop, test on atomic energy to small mechanisms for institute. Two years design, draft car bodies, diesel for manufacturer. Three years Navy (Completed). $10,000. Prefers Midwest, West. Home: Ohio. S(M)-412.

Design, Develop, Test Engineer—Electromechanical Mechanisms: MS Phys Math. Six and one half years direct development, test, research, drafting of small mechanisms for manufacturer. Ten and one half years director of research, development, test, experiments and production of microfilming, and photographic equipment for manufacturer. One and one half years set up research projects and direct research on heating, ventilating for lab. Three years test, design, research, development on controls. $1000 a month. Prefers San Francisco Bay area, West or East. Home: Bay Area. Calif. ME License. S(M)-400.

Additional listings of positions and men available are maintained in the offices of E.S.P.S. Direct inquiries to nearest office. A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members; $4.50 per quarter or $14 per annum for nonmembers, payable in advance.

Designer—Heating, Ventilating, Air-Conditioning Equipment: ME, 38. Four years design, plans, specifications, estimates on heating and, ventilating, air-conditioning, plumbing, steam piping on schools, commercial, and industrial buildings for engineers and builders. Three years design, application, calculations on pneumatic bulk-material-conveying systems, industrial furnaces, heat transfer, electric welding equipment, gate valves for equipment manufacturers. $750. Prefers San Francisco Bay area. Home: East Bay. Calif. ME License. S(M)-352.

Designer, Draftsman—Conveyers, Buildings, Structural: ME and CE training; 30. Seven and one half years detail, design, shop drawings for package conveyers: for manufacturer. Four and one half years drafting, design, detail structural, buildings, service stations, oil refinery plants construction. $485. Prefers San Francisco, Home: San Francisco. S(M)-345.

Develop, Design, Test Engineer—Metal Products: ME (Sweden), 29. One and one half years development, test, radiographs, and ultrasonic equipment. One year teacher mathematics and physics. $475–$500. Prefers San Francsico Bay area Home: Peninsula. S(M)-252.

Sales Engineer—Construction, Maintenance Machinery: ME, 52. Calif. ME License, 26 years' sales of machinery, trucks, and parts to contractors, government, industrials. Salary open. Prefers San Francisco Bay area. Home: San Francisco. S(M)-189.

Plant Engineer—Construction, Steel Plants: ME, 54. One and one half years construction of facilities, maintenance and operation of air bases for government. Five months survey of machine tools in heavy industries for production of war materials and equipment for government. Four years machine design, supervision of installation in aluminum rolling mill, general plant engineering. $9000. Prefers San Francisco Bay area Foreign. Home: Ariz. S(M)-174.

Designer—Missiles, Nuclear, Heat: ME, Aero E, 44. Three and one half years design, experiment, heating computer studies and programming on missiles and airborn components. Two years supervision of research, design of high-temperature-furnace systems, gas generators, heat-transfer analysis for manufacturer. Two years preliminary design, research for nuclear reactors; engineers-scientists. One year supervise design gas and air motors. Three years, sales, research and develop patents. $10,000. Prefers West Coast. Home: Calif. S(M)-166.

Positions Available

New York Office

Vice-President of Sales, mechanical or metallurgical-engineering graduate, considerable sales management, and sales promotion experience covering nonferrous metals and fabricated products. $35,000, plus bonus. East. W7803.

Sales Engineer, 25–35, preferably five years' experience in the field of refrigeration and/or air-conditioning application or service engineering. Prefer a native of Canada. Traveling Eastern Provinces of Canada contacting manufacturers, wholesalers, and contractors regarding application of accessory items used on all sizes of commercial and industrial refrigeration systems. Salary and commission plus expenses. Company will pay placement fee. Headquarters, Midwest. F7806.

Mechanical Engineer or Mechanical-Electrical to head mechanical-electrical section of large consulting engineering firm. Must be able to handle design of mechanical and supervise electrical for dam, waterworks, and sanitary divisions. Company desires to expand mechanical and electrical business so will be expected to do a certain amount of solicitation for new business. Opportunity to grow with established firm and eventually participate. $12,000. Pa. W7809.

Senior Industrial Engineer, 35-45, for a manufacturer of business forms, such as continuous forms, stationery for registers, typewriters, etc. Experience in this line or related line required. Must have ability to supervise and analyze work and be competent to draw conclusions and make decisions and recommendations. Permanent. Salary open. Midwest. W7810.

Engineers. (*a*) Product-development engineers, mechanical graduate, five to ten years' experience. Duties will involve design of new machines and working on wiring devices. Company manufacturers connectors. To $8700. (*b*) Junior mechanical engineer, recent graduate or one to two years' experience. To $6500. Company pays placement fees. Pa. W7819.

Senior Quality-Control and Reliability Engineer, degree in engineering or physics; training in quality control, engineering, inspection, laboratory, and reliability engineering; preferably five years' experience in the these fields. Will head up quality-control and reliability-engineering section; supervise sampling, testing, checking, standardizing, and evaluating. $11,472–$12,816. Location, Pa. W7834.

Project Engineer, chemical or mechanical, process-design background; a minimum of three years' process-design experience, and field experience in either plant construction, operations, or start-up. $8000–$9500. New York, N. Y. W7836.

Production and Methods Engineer, 35–40, at least ten years' experience (to take full charge of present operation) in design, fabrication, and application of small steel products for various lines. Experience should include production control, dies, various types fabricating operations, painting, etc. Opportunity to grow with a small aggressive manufacturer just completing new plant and putting in three new products. Salary open. Employer will pay placement fee. Northeastern Pa. W7839.

Mechanical Engineer, graduate, under 40, two or more years' experience in packaging. Under general direction will design and test packaging and crating for commercial refrigeration products and window air-conditioners. Southwest. W7841-C.

Assistant Packaging-Plant Superintendent, mechanical graduate, at least five years' supervisory production, quality-control, and plant-engineering experience in food, drug, or cosmetic fields. $10,000. New York, N. Y. W7842.

Production Manager, mechanical graduate, at least ten years' supervisory production and equipment-maintenance experience in cement or ceramic-products fields. $10,000–$12,000. N. J. W7849.

Engineers. (*a*) Industrial engineer, graduate, methods, time study, and standards experience covering machine-shop operations. $7200–$8400. (*b*) Manufacturing engineer, IE or ME graduate, at least five years' supervisory production and product-development experience covering lathes and machine tools. $8000–$10,000. Ohio. W7850.

Industrial Engineers. (*a*) Industrial engineer, 35–45, graduate mechanical or industrial engineer with studies covering costs, personnel, administration, and related subjects. Registered engineer in any state. Should have worked for several years in medium and large manufacturing concerns. Several years' of employment by consulting engineering firms of established reputation. Must have ability to gather pertinent data, interpret findings, and undertake development, installation, and supervision of broad phases of industrial engineering. (*b*) Recent graduate engineer with from none to two years' experience, who has potential to develop along lines as afore-mentioned while in training industrial-engineering division. Pa. W7853.

Contracts Manager to handle all incoming mail regarding requests for quotations, handle customer inquiries, for an electronics manufacturer; must be able to establish good customer relations. Will work with production department regarding estimates, follow-ups, institution of contract orders, etc. Some sales experience desirable. Excellent opportunity. To $10,000. New England. W7858.

Design and Development Engineer, mechanical graduate, two to five years' metal-product experience, for product engineering covering skates, golf clubs, fishing rods, and hardware accessories. $6000–$7000. New England. W7861.

Research Engineers. (*a*) Fabrication research engineer, BS, MS, or PhD in mechanical engineering, metallurgy, or metallurgical engineering, minimum of six years' experience in the field of metal processing (press-working, spinning machining, chemical milling, etc.) of high strength steels, titanium, and refractories. Some experience in research and development of metal-fabrication processes and techniques highly desirable. (*b*) Welding research engineers, BS, MS, or PhD. in metallurgy, metallurgical engineering, or mechanical engineering, minimum of six years' experience in welding and/or brazing of high-

strength steels and refractories. Some experience in research and development of metal-joining processes and techniques is highly desirable. (c) Metallurgical engineers, BS, MS, or PhD in metallurgy or metallurgical engineering, experience in field of metal processing or metal joining of high-strength steels, titanium, and refractories. $9000–$15,000. West Coast. W7887.

Sales Personnel. (a) Eastern district manager of field representation for manufacturer of heat-exchanger devices for aircraft, missile, and commercial applications and oil-cooling devices. Will be responsible for co-ordinating plus the managerial portion of work. $8400–$12,840, plus fringe benefits. (b) East coast field representatives, 25–45, engineering degree, two to three years' experience, including working on maintenance of aircraft or service of aircraft, plus sales or service experience sufficient to handle service problems from a technical approach. $6840–$10,200, plus fringe benefits. Headquarters, Midwest. W7890.

Maintenance Engineer for general operations management group, to supervise preventive maintenance program for multiplant company; graduate mechanical, industrial, or electrical engineer, 22–30, some plant experience desired. Will prepare preventive maintenance instructions for all new type equipment, review established program to improve same, make inspections to insure compliance, and assist the superintendent of maintenance of equipment. South. W7891.

Manager, Engineering and Research, 35–45, degree in engineering, design, development, research and administration, managerial responsibility in automobiles, trucks and trailers, farm equipment, heating and ventilating equipment, or other metal-fabricating industries where metal is formed and fabricating in large units. Liberal salary; group and health insurance, retirement plan. Headquarters, Midwest. W7896.

Associate Editor, not over 35, graduate mechanical or electrical, at least two to four years, of power-engineering operating experience in utilities or industry or both. PE license desirable. Also some knowledge of diesel, hydro, refrigeration, air-conditioning, and compressed-air practices desirable. Should be able to write but previous editorial experience not necessary. Some travel. $6000–$9500, depending experience and background. Location, Midwest. W7898.

Engineers. (a) Development engineer for growing company, nationally known, mass-manufacturing-consumer item. At least five years' machine-design and mechanical-development experience in light manufacturing. (b) Administrative engineer, at least five years' experience in machine design and mechanical development in light manufacturing desirable. Salaries open, liberal pension, and fringe benefits. New England. W7907.

Senior Design Engineer, mechanical graduate, at least five years' experience in design and layout of new equipment, or changes to existing equipment which includes the selection of mechanical, hydraulic, and electrical machine components in light process industries. To $9000. Mich. W7915.

Engineers. (a) Chief wage-standards engineer or chief time-study engineer, IE or ME, mature, considerable experience in standard data, incentives, etc. Must have had considerable experience in the metal-working industries. Will report to chief manufacturing engineer. $9000–$11,000. (b) Supervisor of a standard data group, IE or ME degree, five years' experience in the metal-working industries. $5000–$8000. Company pays placement fee. New England. W7918.

Production Manager for company manufacturing complex equipment, utilizing hydraulic, pneumatic, and electrical control components. Should have small-plant experience in all phases mechanical (sheet metal, assembly, machine shop), methods, production planning and control, engineering background, or equivalent practical experience. Newly created key position. Attractive salary and other benefits. Apply by letter giving detailed résumé, including earnings record of last five years. Conn. W7928.

Assistant Industrial Engineer, ME or IE graduate, experience in heavy-steel products fabricating covering production methods, planning, and cost analysis in machining, metal working welding, etc. Salary open. Ohio. W7935.

Chief Engineer, heavy experience in the hydraulic and mechanical fields, who is thoroughly familiar with pumps, valves, and related lines. To head up engineering department engaged in solving special application problems, and in the design and development of new products and product lines. $20,000, plus. New England. W7936.

Chicago Office

Chief Engineer, graduate mechanical or equivalent, 35–55; at least five years' experience in design and development of heavy equipment, to supervise engineering department of approximately 35, including experimental shop, technicians, and draftsmen. Responsible for new and redesign of product. Must have good administrative ability. Company manufactures construction equipment. $12,000–$15,000. Employer will pay placement fee. Ohio. C-7570.

Design Mechanisms Engineer, BSME, to 35, minimum of five years' experience in design and development of precision products, mechanical, hydraulic electrical devices. Knowledge of power assist of servo control automotive or aircraft devices helpful. Duties will include design and development of improved automatic door openers and hydraulic door closers, for electromechanical or electrohydraulic projects; will collaborate with electronics engineer. Work will range from conceptual analysis through field testing and final report. Company manufactures metal-building products. $7560–$9000. Mich. C-7636(a).

Machine-Shop Superintendent, 40–45, for heavy machining operations, to supervise machine-shop operations on tooling, methods, scheduling production, maintenance, and personnel of 75–80. Company manufactures sawmill and water-works machinery. $10,000 and up. Employer will negotiate placement fee. Southern Wis. C-7637.

General Manager, graduate engineer or business administration, to 55, heavy experience in iron, steel, or nonferrous forgings or castings and machining. Functional experience as a line supervisor in production or metallurgy. Must have at least five years' experience as assistant or general manager of an integrated operation or division. Company produces cast-iron and nonferrous castings from medium to large sizes. Will be responsible for production, metallurgy, engineering sales, accounting, etc. Compensation $25,000–$30,000 in total, with part as a base salary and part as bonus and profit sharing. Employer will pay placement fee. Position with a foundry located in Ohio. C-7639.

Hydraulic Engineer, ME degree, three years' experience in hydraulics, knowledge of military specs. Will work on design and development of aircraft, or missile hydraulic components, and/or test and ground support equipment. To $10,000. Employer will negotiate placement fee. Chicago, Ill. C-7644(b).

Senior Machinery-Development Engineer, ME degree preferred; 30–45; seven years' experience in actual machinery design, small automatic machinery preferably. Will design, build, and test automatic machinery. Opportunity of advancement to head of section; manufacturer of spark plugs. From $9000, depending upon experience. Employer will pay placement fee. Mich. C-7653(a).

San Francisco Office

Designer—Electromechanical Packaging and Mechanisms: ME, two to five years' experience instruments, switch, or potential type for the design of small mechanisms and electromechanical packaging; for a manufacturer. Salary open. Northwest. S(P)-4688.

Designer—Cranes: ME, to 50. Well experienced in design of bridge-type cranes, strong emphasis on structural and mechanical portions. Should be able to handle the complete design and work with shop personnel, engineering department, and clients. A responsible position; for a manufacturer. $10,000. San Francisco. S(P)-4686.

Plant Engineer—Light Manufacturer. ME or EE, 30–45. Minimum seven years' recent plant-engineering experience as an assistant or plant engineer in a large organization engaged in light manufacturing or electronic component manufacturing. West Coast men only. About $1000 a month. San Francisco Peninsula. S(P)-4677.

Senior Designer—Conveyers: ME or equivalent, several years' experience preparing design drawings and specifications and handling small contracts. Must have good knowledge of mechanics of materials-handling machinery and equipment. To prepare detailed drawings and layouts of machinery, machine parts, and steel work involving original design and calculations according to customers' requirements, specifications for shop fabrication, estimating, handle orders to fulfill contracts. To $625. San Francisco. S(P)-4674R.

Engineering Department Aide—Mill-Type Machinery: ME, under 35, three to five years' experience relating to heavy machinery; able to provide drawings, specifications, details, for parts, components, or complete machines from old drawings and specifications; also able to supervise drafting, assist, and examine outside drafting work for acceptability. A follow-up job on machinery already installed. For a machinery manufacturer. $600–$700. San Francisco. S(P)-4673.

Designer, Draftsman—Electric Lifts: ME, age open. Minimum five years' experience redesigning parts and components and able to redesign new machinery from initial layouts or sketches. Should have mechanical experience and able to cope with structural, sheet-metal, and mechanical problems on electric-lift unit with gas generator and electric motor. Should also be able to deal with outside suppliers on small parts and body (cab) work and with shop personnel on fabricating and assembly knowledge of auto, electric system, torsion bar, chassis; for a small manufacturer. $700–$750. San Francisco Peninsula. S(P)-4670.

Project Engineer—Semiconductors: ME or equivalent, 30–45. Experience with production machinery for small component manufacturer. Knowledge of design of high-speed production machinery. Direct design project for semiconductor component manufacturing machinery, from original idea to use of machinery in manufacturing. Responsible for complete design. Report to branch manager. For a manufacturer. $7000–12,000 Texas. S(P)-4669.

Methods or Industrial Engineer—Machine-Shop Operation: IE or ME, 30–40, minimum five years' production-shop experience. Must know machine-shop practice, cutting-tool design, and ability to put over new techniques. Permanent position in Calif. About $9000–$10,000 up. S(P)-4667.

Design, Research, Development—Electromechanical: ME, to 50. Minimum two years', or more, recent experience in the field of or directly related to small mechanical design and electromechanical development. For existing or new equipment. For a manufacturer. $650–$800. San Francisco East Bay. S(P)-4628.

Production Superintendent—Electronic Component Manufacturing: ME, EE, Phys. Electronics or Production Management, under 40. Well qualified by current experience to take charge of several-hundred-men production line under the works manager. Should be experienced in electronic components manufacturing and acquainted with semiconductors and their use. Must be aggressive and currently employed in this field. For a manufacturer of electronic components. Placement fee and relocation costs paid. $12,000–$15,000. San Francisco Peninsula. S(P)-4589.

CANDIDATES FOR MEMBERSHIP AND TRANSFER IN ASME

The application of each of the candidates listed below is to be voted on after Oct. 23, 1959, provided no objection thereto is made before that date and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

New Applications and Transfers

Alabama

Knight, Newland D. P., Mobile

Arizona

Dussourd, Jules L., Phoenix
Thomson, Quentin R., Tucson

California

Ender, Herbert, San Francisco
•Gutru, Ronald G., San Mateo
Hazzard, Harry I., Los Angeles
•Johnson, Robert R., Sunnyvale
Kettler, Jack R., Los Angeles
•Kohnen, Keith D., San Francisco
Lowe, Eugene M., Los Angeles
•Mallis, Richard K., Pasadena
Mann, George E., South Pasadena
Mathison, Gordon E., Los Angeles
•McEntee, Jay R., Anaheim
•Meyler, James A., Los Angeles
•Naillon, Pauline M., Walnut Creek
Smith, William R., San Jose
Sudtell, Henry D. W., La Crescenta
Wachter, Elmer E., Jr., Montebello
Williams, Carter P., La Crescenta

•Transfer to Member or Affiliate.

Colorado

Friedell, Morley V., Wheat Ridge
Rivenburg, Henry, Denver

Connecticut

Roberts, Blake G., Greenwich
Szydlowski, Donald F., Bristol

Delaware

Gosline, Carl A., Jr., Wilmington
•Hooton, Edward, Jr., Wilmington

District of Columbia

Devlin, Leighton H., Washington
Lowell, Arthur G., Washington

Georgia

Whitmer, Charles F., Atlanta

Idaho

Conley, John W., Idaho Falls

Illinois

•Bachmann, Robert W., Rockford
Baubkus, Jerome J., Homewood
•Behnken, Harold A., Hinsdale
Bridge, Richard R., Chicago
•Coppock, Max L., Moline
•Milligan, John R., Evergreen Park
•Rost, Thomas E., Crystal Lake
Slowik, Jozef, Chicago
Smith, Thomas A., Peoria
Straughan, William T., Chicago
Voigt, William E., Thornton
Wendt, Frank T., Chicago

Indiana

Szubert, Conrad J., South Bend

Louisiana

McGee, Larkin B., Shreveport

Maryland

Fisher, Philip E., Army Chemical Center
•Ryan, Joseph P., Towson
•Wentworth, William E., Baltimore

Massachusetts

Lalikos, James M., Springfield
May, Daniel H., Jr., South Boston

Michigan

Aldbrink, Eugene F., Jackson

Minnesota

Herring, George D., Rochester

Mississippi

Donnelly, Frank A., Jackson

Missouri

Depp, John M. C., Jr., St. Louis
Leong, Wing, St. Louis

Nebraska

Trenerry, James A., Omaha

New Hampshire

•Barnard, Theodore P., Keene

New Jersey

Shelly, Steven M., Oaklyn
Wood, Charles A., West Orange

New Mexico

Majewski, Eugene F., Albuquerque

New York

•Brooks, Kenneth A., Endicott
Dunn, John C., Brooklyn
Hansen, Arthur G., Williamsville
Hils, Warren D., Tonawanda
•Kornblum, Herbert R., Great Neck
Leggett, Wilson D., Schenectady
Lowell, Chapin M. K., Buffalo
Lusian, Robert G., N. Tonawanda
•Mann, Arthur C., Plainview
Prior, John R., Woodmere
Slaman, Leonard J., Poughkeepsie
•Spina, E. Daniel, Poughkeepsie
Swan, Arthur H., Schenectady
Tumarkin, Joel E., North Bellmore
Vojnovic, Stefan N., Corning

Ohio

•Adler, Arnold R., Cincinnati
Cawley, Lawrence J., Cleveland
•Flanigan, Richard J., Dayton
Garate, John A., Cincinnati
Harter, Russell W., Alliance
Kunz, Walter H., Mount Vernon
Orban, Alexander R., Columbus
Podnar, Lawrence E., Cincinnati
•Wagner, Harold J., Cincinnati
•Wilder, Jesse H., Dayton

Oklahoma

•Pitchford, Albert L., Oklahoma

Pennsylvania

Hunt, Joseph M., Brackenridge
Kerr, Miller W., Pittsburgh
•Peterson, Garfield E., Pittsburgh
Stevenson, Charles H., Philadelphia
Van Kleeck, Ralph E., Philadelphia
•Welch, William P., Philadelphia
Wilkes, Gilbert, 3rd, Philadelphia
Wolfe, James C., Pittsburgh

South Carolina

Lawhon, Robert S., Hartsville

Tennessee

•McLean, David L., Knoxville
•Ward, Charles T., Chattanooga

Texas

Bartz, Richard A., Garland
Bennett, Raymond A., Dallas
•Boone, Thomas G., El Paso
•Bozeman, Herbert C., Houston
•Clark, Cornelius W., Houston
D'Arcy, Robert M., Borger
•Horton, Malcolm A., Waco

Virginia

Booton, John R., Richmond

Washington

Andre, Robert G. C., Mercer Island

Wisconsin

•Garnik, Robert J., Brookfield
Nyberg, Dewey R., Milwaukee
Weathers, Terry M., Sussex

Foreign

Angel, Norman L., Chester, England
Broman, Gunnar E., Trollhattan, Sweden
Chakraverty, Dhabalangsu K., Glasgow, U. K.
Diniz, Victor Y., Resende, Est. Do Rio, Brazil
Guerra-Nozaleda, Antonio, Madrid, Spain
Kirby, John F., Welland, Ont., Canada
Lee, Chi-King, Keelung, Formosa
Millar, Douglas A. J., Otterburn Park, Que., Canada
•Rimrott, Frederick P. J., Montreal, Que., Canada
Segura, Liouel A., Santiago, Chile

OBITUARIES

George Mackenzie Brill (1866–1959), former chief engineer, Solvay Process Co., Detroit, Mich., and Swift & Co., Chicago, Ill., died June 30, 1959. Born, Poughquag, N. Y., March 24, 1866. Parents, Thomas and Mary J. (Hurd) Brill. Education, ME, Cornell University, 1891; MME, 1905. Married Edith Seaman. Assoc. Mem. ASME, 1891; Mem. ASME, 1896, Fellow ASME, 1936. Mr. Brill had been chairman of a board of engineers studying smoke abatement in Chicago. He had also been president of The Empire Knife Co., Winsted, Conn., and of the Williams Tool Co., Erie, Pa. During World War I, he held a commission of Major in the U. S. Army and served as Chief of the Requirements Section and as a consulting engineer to the European Field Command. Mr. Brill, in 1921, designed one of the first refrigeration plants to be installed in Brazil. He served the Society as manager, 1904–1907; and as vice-president, 1910–1912. He was a member also of AIEE and the American Geographical Society and a member of Sigma Xi. Survived by his widow; three sons, Elliot M. of Torrington, Conn., G. Meredith of Slateville Springs, and Roland C. Brill of Brooktondale; six grandchildren; and seven great-grandchildren.

William Adam Crooks (1899–1959), district manager in charge of Chicago Office, Curtis Pneumatic Machinery Div., Curtis Manufacturing Co., Chicago, Ill., died February, 1959. Born, Plymouth, Pa., Aug. 28, 1899. Parents, John and Margaret (Kohr) Crooks. Education, attended Washington University Extension, 1920–1925. Married Mary Ludlow Stout, 1926; two daughters, Mary L. and Caroline M. Crooks. Affiliate ASME, 1944. Mr. Crooks had been a specialist in the fields of production engineering, and plant and sales management. During World War II, he served on the War Production Board. Survived by his widow.

Vicente Carlos Garcia-Moreno, Jr. (1920–1959), plant engineer, Guanos y Fertilizantes de Mexico, S. A., Monclova, Coahuila, Mexico, died June 19, 1959. Born, Ensenado, Lower Calif., Mexico, Feb. 20, 1920. Education, attended University of California. Assoc. Mem. ASME, 1956. Mr. Garcia-Moreno had been employed by the chemical fertilizing company since 1951. He had previously been employed by Industrial Electrica de Mexico, S. A.; Tecnica Industrial de Morelos, S. A.; and Consolidated Vultee Aircraft Corp. He served as an electronics instructor in the U. S. Army Air Force.

Robert Glenville Hughes (1877–1959), formerly with Link-Belt Co., Houston, Texas, and designer and builder of many commercial buildings in the north Jersey area, died June 25, 1959. Born, New York, N.Y., Sept. 27, 1877. Education, ME, Stevens Institute of Technology, 1898. Mr. Hughes was known in art circles for his work in sponsoring New Jersey art exhibitions. At one time he served as Commissioner of Public Works of Paterson, N.J. Survived by his widow; two sons, John S. and Robert G. Hughes, Jr.; a daughter, Mrs. Howard Devree; and a sister, Mrs. Bertram Saunders. Mem. ASME, 1908.

Henry Hamilton Kerr (1892–1959), retired vice-president, operating dept., Toledo Edison Co., Toledo, Ohio, died June 13, 1959. Born, Fort Worth, Texas, Jan. 18, 1892. Parents, Henry H. and Mary E. (Payne) Kerr. Education, BS(ME), University of Colorado, 1914. Married Helen J. Clancy, 1925. Mem. ASME, 1925. Fellow ASME, 1958. Mr. Kerr, who retired from Toledo Edison in 1958, had been with the utility since 1929. He was among the first to promote the use of lignite in pulverized-coal firing of central power-plant boilers in Colorado, a practice that has been continued to this day in areas where lignite is readily available. He was a pioneer in the promotion and use of automatic substations in the transmission and distribution of electric energy. As the inventor of a system that interlocks the primary and secondary circuits on network transformers, Mr. Kerr had made important contributions to the safety of personnel and equipment, and the improvement of service. He was responsible for his company's contact and follow through in the study leading toward the development and construction of a fast neutron breeder reactor. Mr. Kerr was a fellow and a vice-president of AIEE; a past-president of the Engineering Society of Toledo; and was active in engineering development work with the Edison Electric Institute and the Association of Edison Illuminating Companies. He served the Toledo Section ASME on its Executive Committee and as chairman. He was a past-president of the Riverside Hospital board of trustees and a past vice-president of the Toledo Area Chamber of Commerce. Surviving are his wife, Helen J.; two daughters, Mrs. Mary Hamilton and Barbara Kerr; and a brother, Francis Kerr.

Theodore Kroin (1937–1959), junior engineer, Research and Advanced Development Div., AVCO Manufacturing Corp., Wilmington, Mass., died in an accident, June 17, 1959. Born, New York, N.Y., July 3, 1937. Parents, Mr. and Mrs. John Kroin. Education, BS(ME), Cooper Union, 1958. Assoc. Mem. ASME, 1958. Survived by his parents and a brother, Joel.

Nathan Joseph Levy (1901–1959), chief, time study dept., Newport News Shipbuilding and Drydock Co., Newport News, Va., died June 12, 1959. Born, Newport News, Va., Feb. 9, 1901. Education, attended Virginia Polytechnic Institute as a special student, 1923–1924. Married Sarah Omansky. Mem. ASME, 1950. Mr. Levy joined the Newport News firm in 1924. He was a leader in his community having served as a member of the Virginia State Chamber of Commerce and the Planning Commission and Board of Zoning Appeals. He was chairman of the Warwick Highway Safety Committee. Mr. Levy was an active member of the Peninsula Sub-Section of the Virginia Section ASME. He was a member also of SNAME. Survived by his widow; two sons, Mayer G. and Philip M. Levy; one brother, Philip Levy; and two sisters, Mrs. Jack Amelson and Mrs. Leonard Cohen.

Ralph Carroll Nourse (1892–1959?), consulting engineer, Mechanical Enterprises, South Gate, Calif., died recently according to a notice received by the Society. Born, Quincy, Mass., Nov. 23, 1892. Education, BS(ME), Worcester Institute of Technology, 1915. Mem. ASME, 1948. Mr. Nourse was a designer of special machinery, industrial buildings, hydraulic equipment, tanks, and the like.

James Preston Percy (1893–1959), general superintendent and chief engineer, Central Aguirre Sugar Co., Aguirre, Salinas, Puerto Rico, died June 3, 1959. Born, Chino, Calif., Sept. 6, 1893. Parents, Hugh and Nellie (De Nice) Percy. Education, high-school graduate and ICS. Married Dolores A. Artesani, 1930; two children, Eleanor and Frances Percy. Assoc. Mem. ASME, 1925; Mem. ASME, 1930. Survived by his widow who resides in Silver Spring, Md.

Edward Alan Reineman (1930–1959), manufacturing engineer, Computer Div., General Electric Co., Phoenix, Ariz., died recently according to a notice received by the Society. Born, San Diego, Calif. March 26, 1930. Education, BS(ME), University of Arizona, 1958. Assoc. Mem. ASME, 1958.

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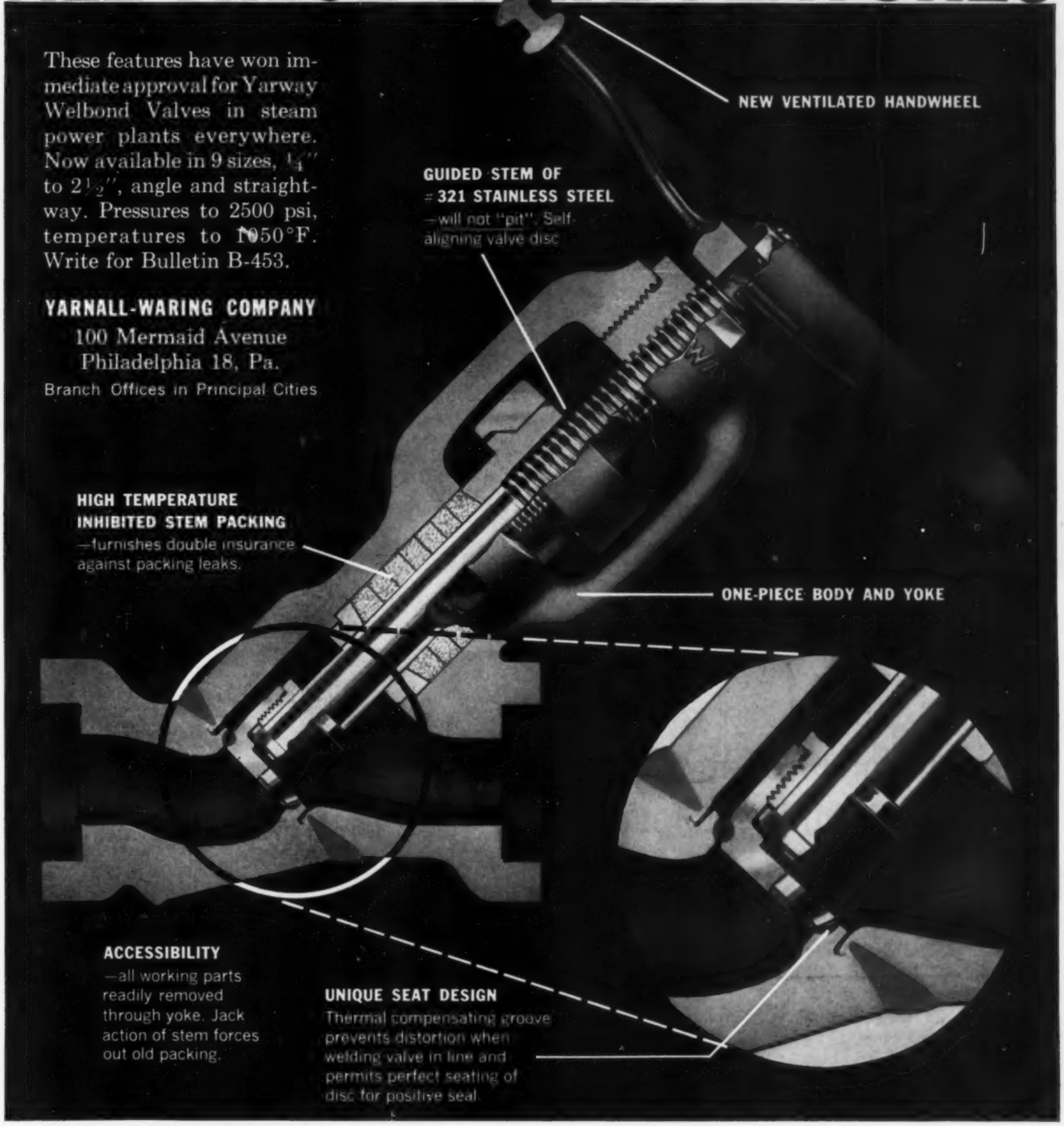

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NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

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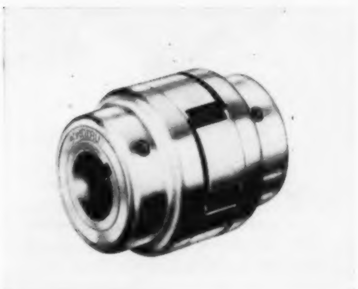
NEW EQUIPMENT



Insulated Couplings

Charles Bond Co., announces the manufacture of a new line of aluminum Bondtru flexible insulated couplings for light-duty applications.

The couplings are manufactured in six sizes with 20 standard bore sizes ranging from 1/4 to 1 1/2 in. The firm says other than standard bore sizes and taper bores are available. They are furnished with keyways and set-screws. They will transmit up to 10 hp at 1800 rpm.

The couplings have two aluminum flanges with projecting segments that engage each other through a non-metallic insert which carries the load in compression. The non-conducting insert is designed to eliminate both static and dynamic electricity, absorb shock and torsional vibration. All edges of the couplings are rounded. **—K-1**

Instrument Counter

A precision type counter having all of its supporting structure inside the wheels has been developed by Veeder-Root, Inc., Hartford, Conn.

The case has an integral barrel on which the wheels are mounted. All of the supporting structure is inside. The firm says the new model will therefore fit inside the customer's instrument or adapt readily to any application requiring light weight, minimum size and ruggedness.

Its numerals are available in 0.156 or 0.188 in. height and come standard enamels or fluorescent paints. They are available with three to five wheels. **—K-2**

Drawing Desks

A new high-style walnut drawing desk group, The Landmark, has been developed by Hamilton Mfg. Co., to meet both the functional and esthetic requirements of architects, designers, engineers, and draftsmen.

A feature of the new unit is an attached side auxiliary unit which offers tool, catalog and tracing storage and a space-saving working area just a quarter-turn from the desk. The auxiliary unit principle is based on time-and-motion studies which reveal a high correlation between nearness of working tools and materials and productivity.

The Landmark's style features are its walnut-paneled sides with contrasting off-white drawing-work surfaces and satin chrome trim. A prototype model, shown for the first time at the recent Design Engineering Show in Philadelphia, was judged one of the exposition's 11 best-designed new products.

Adaptable for either individual offices or for prestige multiple installations, The Landmark has three basic components: a front table, basic table and rear reference desk.

The front table can be used alone in an office or to head a row installation. It has an adjustable drawing board but no storage area in front. The basic table combines drawing and reference areas. This unit placed behind a front unit offers a reference surface and storage area for the front man and a drawing surface for the second.

The row can be continued with as many basic tables as required. The last man is furnished with a rear reference desk. **—K-3**

Control Drives

A new, high torque control drive has been included in a revised version of product specification P81-1, available from Bailey Meter Co. Four sizes, producing torques from 50 to 2250 ft-lb, and suitable for special high temperature applications to 250 F are described. **—K-4**

Self-Sizing Fasteners

A new line of self-broaching and self-sizing fasteners, designed to automatically produce optimum interference-fit installation, is now available from Huck Mfg. Co.

Both the self-broaching and self-sizing designs have the same shear and tension values as close-tolerance Huckbolt fasteners of equal diameter in AISI 4037 material. The same collars are used with the new pin designs. In addition, the same inspection gages are used; on inspection, the installed self-broaching or self-sizing fastener is identical in every way to the firm's established fastener design. The new pin designs are recommended by the company for use in joining aluminum alloy components. **—K-5**

Vent Exhauster

A new motorized vent exhauster, developed by Reznor Mfg. Co., is designed to provide economy and flexibility of gas unit heating in office buildings, older manufacturing plants and multiple-story warehouses.

The venter vents exhaust gases from unit heaters directly to the outdoors through the side wall of the building. The firm says it requires only a short length of standard, lightweight 4-in. pipe.

The venter also may be used for floor model direct-fired heaters in the home. In residential applications, the exhaust is taken through a hole in the floor, and then carried out under the floor to the outside.

Powered by a permanently lubricated, fan-cooled electric motor, it is thermostat controlled. The Model V300 is used with heaters from 25,000 up to 300,000 Btu input. An adapter is used for attaching the venter to the flue. Sizes are available for all the firm's heaters. Adapters have built-in restrictors to control the volume of gases drawn through the exchanger, and to provide efficient combustion. **—K-6**

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BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Pressure Gages

A new series of pressure gages, known as the Master-test line, has been announced by Marsh Instrument Co., Skokie, Ill.

Made in all standard pressure ranges, and in compound and vacuum types, the new series of gages are individually deadweight tested and guaranteed accurate within $^1/_4$ of 1 per cent plus or minus of the maximum dial reading over the entire range.

A new type of dial, called the Read-easy dial, has been developed in which the inner arc shows major markings, as shown in the illustrations, and the outer arc the fine graduations. This permits the gage to be read with the accuracy of a caliper rule, the firm reports. **—K-7**

Atomizing Spray Nozzles

Spraying Systems Co., 3265 Randolph St., Bellwood, Ill., has introduced a new line of atomizing nozzles made of hard rubber for corrosive liquid spraying applications.

The nozzles produce a hollow cone spray pattern and atomization is accomplished through hydraulic pressure alone. A range of capacities are offered from 1 to 26 gph based on operation at 40 psi.

All parts of the nozzle are made of hard rubber, offering maximum resistance to acids and related corrosive liquids. They are identified as $^1/_4$ NR atomizing nozzles. **—K-8**

Stainless Swing Joints

Stainless steel swing joints available from OPW-Jordan are designed for use as elbows in pipe lines wherever flexibility and rigidity are both needed.

The Series 7400 joints are available in $1^1/_4$-in. sizes in 17 different styles. They are cast in 316 stainless steel and designed for 1000 psi service. Temperature is determined by the O-ring seal, available in such materials as Viton, Buna-N, neoprene, butyl and Teflon. **—K-9**

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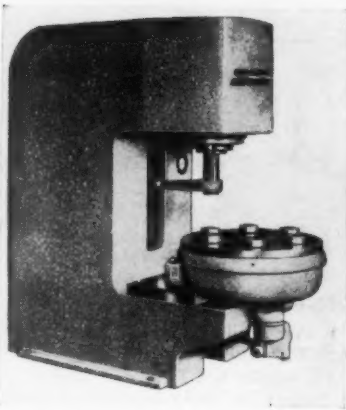

Hydraulic Press

A new line of Series T hydraulic multi-presses, in capacities from 4 to 12 tons, has been announced by Denison Engineering Div., American Brake Shoe Co.

The new presses, which are self-contained bench units, have a more rigid frame, larger bed area and more knee room than earlier models, the firm reports. The unit, designed to meet JIC specifications, has an accessible relief valve for providing adjustment of ram pressure. A newly designed cylinder provides faster operating speed, and a quick-adjusting inch and stroke change control is provided.

The presses are available with manual or automatic controls, and are designed for use with the firm's 6 or 12 station indexing tables. Overall height of these presses is $52^1/_2$ in. without the bench; weight is approximately 1800 lb; finish is green sparkle. **—K-10**

Hydraulic Damper Regulator

A new damper regulator, which also regulates fans, stokers, oil and gas control valves and is suitable for use on any boiler that operates at pressures from 5 to 150 psi, is available from Atlas Valve Co.

The firm says the device may be used to actuate lever-operated balanced valves for pressure regulating service, either reducing or unloading.

It repositions dampers and lever-operated valves in response to small changes in the controlled pressure. Adjustment of the controlled pressure is made by adding weights or removing them from the lever of the regulator. Minute changes are accomplished by repositioning the sliding weights.

The company says the regulator, which continuously maintains the desired boiler pressure with narrow limits by automatically adjusting boiler draft, moves the damper on pressure changes of as little as $^1/_4$ lb.**—K-11**

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BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Silicon Rectifiers

A new, small silicon power rectifier, the Style 20, is available from Syntron Co.

The rectifier is a fused alloy device. It is designed for operation at current levels from 1 to 15 amp (single phase half wave average). Surge ratings are 90 amp average at 6 cycle (.1 sec) and 50 amp average at 60 cycle (1.0 sec).

Peak inverse voltages range from 50 to 400 v in 50 v steps. Temperature range is from −65 to +175 C.

The unit is mounted on a $^{7}/_{16}$-in. hexagon stud type case with a glass to metal seal cap. Maximum height is $1^{3}/_{16}$ in. **—K-12**

Centrifugal Disc Clutches

A centrifugal disc clutch with a new design feature has been announced by United Specialties Div. of Industrial Enterprises, Inc. Called Centri-Disc, the clutch incorporates a levered-fly-weight design that is said to triple the effective centrifugal forces and therefore permit smaller clutch size or motor size.

Other advantages are described in Bulletin CD-1. Applications include air conditioners, conveyors, drills, elevators, speed reducers, pumps, and industrial fork-lift trucks.

—K-13

Modular Controls

Development of a modular control package consisting of magnetic pre-amplifier, power amplifier and module case has been announced by Airborne Accessories Corp.

The unit, which contains no moving contacts or relays, is said to be applicable to systems in the aircraft, missile, electronic control and related fields.

Circuitry for the pre-amplifier and the power amplifier in each design is mounted in a compact chassis which can be slid in or out of the standardized module case in seconds by means of a quick connect-disconnect plug. Power amplifiers drive motors ranging up to 200 watts.

The package is assembled entirely from standard units. Module case (2-module stack) measures 5.0 × 3.1 × 3.7 in. (flange 5.4 × 4.2 in. base). Magnetic pre-amplifier weighs 0.8 lb, has a chassis operating temperature of 125 C. Gain is 200 v/v. Power output is 18mw. **—K-14**

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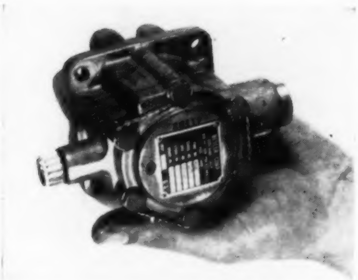
BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS



Regulator Valves

A new development in regulator valves, designed to hold pressures in tanks to within one-tenth of a pound despite varying inlet pressures, is announced by Besler Corp.

Basic design of the pressure control valve may be adapted to a variety of sizes and pressure settings, the firm reports. It operates from zero to 300 psig. Full flow is maintained within two-tenths of a pound above cracking pressure (full flow to zero leak reseat in three-tenths of a pound).

The valve functions efficiently in a temperature range from −65 to 480 F. The firm states that almost any kind of gas or fluid can be regulated. With exotic gases and fluids the internal parts can be changed with minor modifications to meet the conditions. **—K-15**

Carbon Steel Tubing

Leaded C-1020 carbon steel tubing, characterized by outstanding machining properties, has been announced by Superior Tube Co.

The addition of .15 to .35 per cent lead to the C-1020 analyses increases the machinability from 72 to 85/90 per cent and the surface feet per minute cutting speeds from 120 to 140/150 sfm, the firm reports.

It is stated that there is virtually no difference in physical and mechanical properties between leaded and non-leaded C-1020. The company says the leaded grade is preferred wherever the savings from increased production offset somewhat higher material costs, as in most screw machine operations. **—K-16**

Air Line Filter

Watts Regulator Co. has introduced a new air line filter which drains automatically.

Using the pilot principle, the filter incorporates a float which admits air to a pilot valve chamber whenever liquid accumulates, opening a scavenger valve. Trapped liquid and impurities are then blown out the drain opening.

The new Auto Drain filter is available in sizes from $^1/_4$ through 1 in. Transparent plastic bowls are supplied for pressures up to 150 psi; metal bowls to 250 psi. **—K-17**

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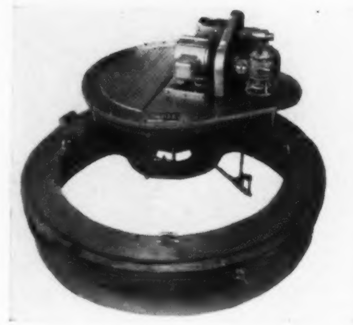
BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS



Liquid Clarifiers

A horizontal spur-gear drive for heavy-duty applications of the Rota-Rake clarifier and thickener has been developed by Graver Water Conditioning Co.

It has been designated Model C and joins three other drives available with the Rota-Rake. The unit is a horizontal flow water and liquid treatment unit for gravity sedimentation and sludge thickening.

The new drive head is a heavy-duty unit with a completely enclosed, integral gearing arrangement. The gears, operating in an oil bath, are of Meehanite cast iron as is the housing. Anti-friction ball and roller tapered bearings are used throughout and the pinions are of forged steel. **—K–18**

Pinion Chuck

Skinner Chuck Co. announces a new chuck, utilizing combination of a pinion gear plate, screw and wedge, assigned to combine the desirable features of hand and power chucks.

The company claims the new chuck has accuracy within .001 total indicator reading, repeatability without adjustment within .0005 total indicator reading, unequalled gripping power, and no size limitations.

In operation, the pinion, which can be turned either by hand or by a power wrench, engages the gear plate causing the screw to move the wedge. The action of the screw on the wedge controls the chuck jaws. The force of the wedge on the jaws holds the work with tremendous force, the firm states.

Additional features which company claims for its new chuck are a shear pin that keeps the chuck from being tightened beyond capacity, an eccentric fail-safe mechanism which locks rotation if the shear pin should break, a self-locking mechanism that prevents the chuck from opening under any load or centrifugal force conditions, a center hole to permit bar stock chucking, sealed operating mechanism, and lubrication fittings. **—K–19**

For Consulting Engineers Turn to Page 216

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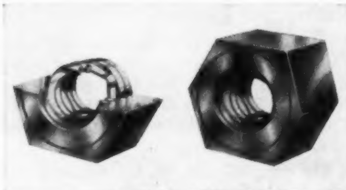
BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS



Aluminum Locknut

Waltham Precision Instrument Co. introduces a new self-locking aluminum locknut called Tru-Lok.

The nut incorporates a high strength, spring-temper stainless steel (18-8, FS304) wire form in an aluminum (24ST-6) body. The firm say this combination provides the properties to meet all the performance requirements of MIL-C-25027 for 550 F operation as well as 250 F.

Specific configurations shaped into the middle winding of the coil produce accurately controlled pressure, exerted uniformly and radially, for unvarying torque and locking friction that assures vibration-proof, constant position. —K-20

Water Control Valve

A new ring-jet valve designed for easy regulation and control of water under free discharge has been announced by Allis-Chalmers, Milwaukee 1.

The firm says the new design retains most of the advantages of the Howell-Bunger valve in that it provides easy free discharge regulation with high discharge coefficient. It is equipped with a hood to minimize the spray and to admit air to the jet. Standard dimensions of the valve available in 17 sizes from 18 to 108 in. are given in Bulletin 02B9154. —K-21

Pelletizing Disks

Production of a standard line of pelletizing-mixing disks for continuous agglomeration and mixing of a wide variety of fine granular solids has been announced by Dravo Corp.

The disks will be made in four basic sizes—3-ft 3-in. diam, 8-ft 6-in. diam, 12-ft diam and 16-ft 6-in. diam. The smallest size disks will be stocked by the firm for sale or short-term rental for use in pilot plant studies.

The units were developed and designed by Lurgi Co., Frankfurt, Germany, and adapted to American standards. The disks are said to be equally effective for either pelletizing or mixing. They are used extensively in the steel and mining industries for the agglomeration of ore concentrates. When employed for mixing, the disks are run at substantially higher speeds and thus can handle large volumes of material in relatively short times. —K-22

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BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Distribution System

A new electrical distribution system called Uni-Bus Masterguard, for industrial plants, commercial and institutional buildings has been announced by Electric Distribution Products, Inc., Allentown, Pa., a subsidiary of Worthington Corp.

The company says the unit is a new concept which provides such a degree of safety that it is impossible to touch a live part anywhere in the system. The system's exclusive safety slide and retractable plug-in contact operation is described in literature which includes AIA File No. 31-C-621 available from the company.

In operation, a safety slide covers bus bars, and cannot be opened until plug-in unit is installed on busways. When the plug-in unit is installed on busway, and safety slide is open, interlocks prevent removal of plug-in device. Retractable stabs make contact with bus bars when handle is "on" and door to plug-in unit cannot be opened. When handle is "off", door can be opened—stabs automatically and instantly snap from bus bars. The plug-in unit is entirely dead for safe removal from busway after safety slide is closed.

The electrical bus bars with close bar spacing, maintain low voltage drop, and are used for power transmission throughout the system, even in control centers and safety switches. The busways also have a duo-circuit arrangement combined with close bar to give high momentary short circuit strength and low impedance. All conductors are fully insulated to eliminate power arcs.

The firm says the system contains two major design innovations: all components of the busways' system have common electrical ratings and physical dimensions to permit unlimited flexibility in system planning; standardized sub-distribution centers receive a variety of plug-in units to make them perform the same electrical functions of several products used in ordinary systems. **—K-23**

Thread Root Form

A new thread form claimed to double fastener fatigue life under dynamic loading has been added to the Unbrako socket head cap screw line of Standard Pressed Steel Co., Jenkintown, Pa.

The firm says the big change in the new thread form is its smoothly radiused root. This is designed to greatly reduce failure-producing stress concentrations in a section of a tension screw—the least cross-section of the thread—where an estimated 85 per cent of fatigue breaks occur.

As shown by calculations of $^1/_4$-28 size threads, the stress concentrations in the conventional flat root are as much as 6 times those in the smooth shank of the stressed screw. By comparison, the new radiused root—called Hi-Life by SPS—scales stress concentrations down to a factor of 3.4. **—K-24**

KEEP INFORMED — BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Center Column Machine

A special 16-station center column machine designed to perform milling, drilling, spot-facing and tapping operations on six different cast iron fuel pump covers is announced by Snyder Corp.

The machine is also designed to produce the same parts when made of aluminum. Production rate is 81 cast iron parts per hour at 100 per cent efficiency.

The company explains that the differences in the six parts lie in the number of holes and location of the holes in the part. To handle these parts with minimum changeover time, the firm devised a method of utilizing multiple-spindle drill heads that provide spindles for drilling all of the holes in the six different covers. Thus, to change over from one part to another is merely one of inserting or removing tools from certain spindles.

Speed and feed change gears or V-belt pullies in the firm's standard milling, drilling and tapping units accommodate the change from cast iron to aluminum parts.

Both sides of the fuel pump covers are milled and drilled. This is accomplished by utilizing eight two-position fixtures that are indexed through sixteen machining stations. In one position in each fixture the part is clamped with the top side up. The bottom side is up in the other clamped fixture position.

At the loading station the operator removes a finished part from the second fixture position, moves a partially-finished part from one fixture position to the other and loads a rough part in the first position. A two-jaw chuck with V-type serrated jaws clamps the rough part in the first position. A pair of bayonet-type toe clamps holds the part down on a milled face in the second fixture position. —K-25

Push Hose Fitting

A new line of fittings and industrial hose for air, water, oil, and fuel service at pressures under 250 psi is announced by Parker Fittings & Hose Div.

The fittings have been given the trade name of Push-lok. Two types of hose are available for use with the fittings. No. 821 hose has fiber braid reinforcement and cotton braid cover. No. 831 hose has fiber braid reinforcement and abrasion-resistant rubber cover. Five sizes are offered from 1/4 through 3/4 in. id. Temperature range is from −65 to +250 F except for air which is 160 deg max.

Fittings with seven different connecting ends are offered: male pipe thread; Triple-lok end to connect 37-deg flared tube; 45-deg cone to connect 45-deg flared tube; swivel nut to mate with Triple-lok 37-deg cone; swivel nut to mate with 45-deg cone; inverted 45-deg flare seat; and inverted swivel nut to mate with inverted 45-deg flare fitting. —K-26

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BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Spline Drive Armatures

A new line of spline drive armatures for use on integral horsepower electric clutch-coupling and brake applications where shock-loading or vibration-loading are problems is announced by Warner Electric Brake & Clutch Co.

Spline drive armature assemblies are immediately being made available in 8, 10, 12 and 15-in. diameters. They can also be used on many special clutch applications where the equipment builder or user furnishes the male splined hub, the firm reports.

According to the company, no mounting adjustment is required. The armature is pressed tight against the magnet face at the completion of mounting and on release the airgap is set automatically by the autogap spring.

The splined armature adapter made of Meehanite is bolted to the armature using buttonhead socket screws and lock nuts. The internal involute spline which is cut in the adapter is lubricated with molybdenum disulfide for initial break-in and needs no further lubrication. The alloy steel splined hub has a tapered bore into which the tapered bushing is pressed giving the equivalent of a shrink fit. A retainer ring at one end of the hub prevents the armature from being backed off too far.

A split, tapered bushing is used to fasten the splined hub to the shaft. Either two or three capscrews (depending on bushing size) are placed through the clearance holes in the bushing flange and threaded into the tapped holes in the splined hub to draw the bushing into the bore of the splined hub.

These same capscrews function as "pullers" to remove the bushing from the splined hub by being threaded through tapped holes provided in the bushing flange and bearing down against the splined hub. **—K-27**

V-Belt Drives

New compact V-belt drives have been developed by The American Pulley Co., Philadelphia. The firm says the new drives, called American 3-5-8, utilize improved V-belts with cross sectional areas reduced nearly 50 per cent with no loss in life expectancy.

The three belt cross section sizes used in the drives replace five sizes needed with previous drives. Each belt cross section has been fitted to a particular horsepower range: 3-V belts ($^3/_8$-in. top width) handle drives from 1 to 50-hp; 5-V belts ($^5/_8$-in. top width) handle drives up to 200-hp; and, 8-V belts (1-in. top width) transmit up to 1500-hp. **—K-28**

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BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Conveyor Belting

A low-cost, high-quality friction surface conveyor belting introduced by United States Rubber Co. is claimed to promise longer life than similar types of belting currently being used by industry.

The new belting, called Indestructible Slab, is designed to operate where other friction surface, woven duck or stitched canvas belting is currently employed. The firm says that on other jobs where transmission belting is used because of cost limitations or especially tough operating conditions, the new belting should offer better service at comparable or lower costs.

Use of the highest grade rubber frictions, uncommon in this type belting's price range, makes the belt harder to tear up or wear out, the company states. Extra thick skim coats of natural rubber are designed to check wicking and block edge ravel.

The fabric component of the new belting is also said to be superior for its price range. Full-strength standard cotton duck is used, rather than light-weight sheeting employed in other belts of this type, for added lengthwise strength and resistance to side travel.

Available in three or four-ply construction, the new belting is bright orange in color. It has a non-staining surface that also is resistant to mild acids such as those in citrus fruits. Because of its supple natural rubber construction, the belting can easily flex around the small pulleys which are standard on package conveyors.

The new belting can also be used for slider bed service where the belt operates over hard wood or metal surfaces, or as a drive belt on live roller conveyors. **—K-29**

Metal Turnings Crusher

A new rolling ring-metal turnings crusher for capacities up to $1^1/_2$ tons per hour is now being marketed by American Pulverizer Co., St. Louis 10, Mo.

Designated as Model 1800, the new product has been specifically designed for plants producing up to 200 tons or more per month of any type of metal turnings—alloy steel, carbon steel, aluminum, brass or bronze. A bulletin is available from the company. **—K-30**

Dust-Tight Magnets

Availability of dust-tight magnet covers for its complete line of electromagnetic vibrating feeders is announced by Syntron Co.

The covers consist of long-life rubber gaskets and metal plates which are easily bolted in place over the openings of the magnet housing. The firm says that because the electromagnet drive contains no wearing mechanical parts to require lubricating or other servicing, the dust-tight covers seldom need to be removed. **—K-31**

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BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Magnet Chain Assemblies

Accoloy No. 125 steady-lift magnet chain assemblies, designed to accommodate electrically-energized magnets of all sizes and lifting capacities, have been introduced by American Chain Div., American Chain & Cable Co., York, Pa. The firm says that because of the rigid section of the master link, the crane operator can pick up or deposit the assembly at any location in the plant or yard without having any crane follower or other employe handle it. Tripod construction is designed to prevent chain damage due to twisting. All legs are replaceable in the field, being connected to the master alloy casting with square-end pins. These pins prevent rotation, thereby eliminating wear of casting at attachment points, the company reports.

Peening of end links is reduced by use of drop-forged alloy steel stud links at the extremities of each chain leg. Conventional end links are said to allow excessive amounts of slack which damages these links when the crane operator lifts the magnetized load. The units are available in 1 and $1^1/_4$-in. chain assembly sizes. **—K-32**

Inertial Damped Servo

Kearfott Company, Inc., has announced the availability of a size 15 high temperature inertial damped servomotor.

The firm says the unit, designated T1311-22, operates effectively at temperatures ranging from -54 to $+200$ C.

The unit consists of a standard servo motor to which a drag cup integral with a rear shaft extension has been added. The need for viscous dampers is eliminated without reducing no load speed and without increase in steady-state errors in position servo applications, the company reports. There are no controls to adjust, phasing problems are obviated, and null or pick-up problems are removed, the firm states. **—K-33**

Magnetic Starter

Furnas Electric announces a magnetic motor starter, rated through 15 hp 440–550 volts, incorporating new control features.

The firm says all components are front removable, dual voltage coils are reconnectable on the job, and trip-free thermal overload relays with trip indicator are featured on the new unit.

Field modification kits are available to add push button or selector switches, pilot light, auxiliary contacts or third overload relays to a basic starter. The encapsulated duel voltage magnet coils are moisture and fungus resistant and are rated 110–220 or 220–440 volts, 50–60 cycles. A molded terminal board in each coil is designed to eliminate leads and simplify coil voltage selection. The coil accepts plug-in push button or selector switch. **—K-34**

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BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Speed Reducers

Cleveland Worm & Gear Co. announces a new line of high horsepower speed reducers said to be capable of transmitting as much as 80 per cent more horsepower above that carried by conventional worm gear units. The firm has already placed in production smaller-sized speed reducers ranging from 1 to 40 hp.

Housing is one-piece design of cast iron, ribbed for maximum strength and heat dissipation. Cooling fan of unique design is mounted on input end of worm shaft and is designed to be equally efficient in either direction of rotation.

Worms are cut integral with shaft and accurately ground to a high surface finish on both thread flanks. Shaft extension diameter is especially large to permit increased overhung load capacity. Heat treating is by means of an acetylene-oxygen flame at 3300 F.

Gears have centrifugally cast bronze rims with a high tin-nickel content, made integral with a cast iron center. Centrifugal cast bronze results in a greater density and a higher hardness. **—K-35**

Gas Drying System

American Instrument Co., 8030 Georgia Ave., Silver Spring, Md. announces a new high-pressure gas-drying system said to contain new and unique features for missile ground-support installations where super-dry gas is a prerequisite.

The new system contains a drier, hygrometer moisture indicator and Corbin diaphragm-type compressor. Equipment is available mounted on a common base, or as separate components.

The drier is a completely automatic dual-assembly, one side of which furnishes super-dry gas to the system, while the other side undergoes reactivation. The drying chambers use "Molecular Sieve," described as the most efficient drying agent known, capable of drying and delivering gas for months without replacement, to dew-points as low as minus 100 F and lower. The apparatus incorporates both a drying tower, and dust filter. **—K-36**

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Box Wire Coils

Flat coppered box stay wire has been made available on a new 50-lb coil, according to an announcement by Prentiss Wire Mills, Riverside-Alloy Div., H. K. Porter Co.

The new coils have doubled the conventional coil size, and are said to be ideal for large automatic stitchers. It has been estimated that the 50-lb coil contains enough wire to deliver 106,000 stitches. Based on an average of one inch per stitch and six stitches per carton, the new Prentiss coil could staple 17,800 cartons without downtime, the firm says. **—K-37**

Coal Scale

A new size automatic coal scale, with a 1000-lb unit capacity, has been developed by Richardson Scale Co.

The firm says a special feature of the scale is greater accessibility provided to all critical parts by a total of eight access doors—two more than on the standard models. These doors permit quick removal of the weigh hopper and easy access to any part of the scale for inspection or adjustment, the company says. They have special linings and mountings to prevent coal dust from falling to the floor when the door is opened.

Constructed with heavy steel angles on the frame and plates of heavy-gage sheet steel, it has an hourly capacity of 60 tons. **—K-38**

Insulated Gas Cocks

Wedgeseal-insulated, iron body brass core gas cocks with male or female thread union ends are now offered by Eclipse Fuel Engineering Co., Rockford, Ill. The new units are said to eliminate coupling and nipple in virtually every installation. Currently offered in the $^3/_4$, 1, and $1^1/_4$ in. sizes, they are available in either standard or "retained key" (tamperproof) construction, with flat head or lock wing and in black or galvanized finish.

The firm explains that Wedgeseal construction features an insulator made of Zytel 105, molded as a permanent part of the union tailpiece in both internal and external thread styles. There is no separate insulating collar to be left out of the assembly; the insulator itself is used in compression only, will not shear, pull out, or crack in service. All threads are in metal. Design of the insulator eliminates any possibility of metal-to-metal contact, of jumping or shorting, the company reports.

The insulator is claimed to provide complete protection from stray or induced house currents; is not affected by natural, manufactured or LP gases; and is weather-resistant. It is stable at temperatures up to 400 F and suitable for continuous operation at 275 F. **—K-39**

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K-1	K-12	K-23	K-34	K-45	K-56	K-67	K-79	K-90
K-2	K-13	K-24	K-35	K-46	K-57	K-68	K-80	K-91
K-3	K-14	K-25	K-36	K-47	K-58	K-69	K-81	K-92
K-4	K-15	K-26	K-37	K-48	K-59	K-70	K-82	K-93
K-5	K-16	K-27	K-38	K-49	K-60	K-72	K-83	
K-6	K-17	K-28	K-39	K-50	K-61	K-73	K-84	
K-7	K-18	K-29	K-40	K-51	K-62	K-74	K-85	
K-8	K-19	K-30	K-41	K-52	K-63	K-75	K-86	
K-9	K-20	K-31	K-42	K-53	K-64	K-76	K-87	
K-10	K-21	K-32	K-43	K-54	K-65	K-77	K-88	
K-11	K-22	K-33	K-44	K-55	K-66	K-78	K-89	

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BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Hydraulic Shears

A new line of metal-cutting shears that make use of hydraulic power has been developed by the Steelweld Machinery Div., Cleveland Crane & Engineering Co.

The firm says the new shears are different from other hydraulic shears in two basic respects: the blade is powered by a single hydraulic cylinder; and the blade is pivoted and turns in a curved path.

The single cylinder applies constant force throughout the cutting action by means of a cross shaft that links the piston rod to the two ends of the blade.

According to the company, use of one cylinder greatly simplifies the hydraulic circuit. This cylinder need only be of a size comparable with either of the two used on a two-cylinder machine. No special circuits are needed to keep the blade level, since the blade is kept level by the mechanical linkage. **—K-40**

Straight Side Press

The firm's line of straight side, single action hydraulic presses has been expanded to cover a 25 through 1000-ton range, according to K. R. Wilson, Inc., the machines are designed for trimming, bending, forming, blanking, briquetting, broaching, coining, embossing, forging and straightening.

The presses feature rigid, welded steel construction. Frame members are keyed and fitted together to insure maximum resistance to deflection. The company says angle gibs are located at each corner of the platen to insure platen-to-bed parallelism for accuracy and long die life.

The firm's hydraulic systems can be mounted at the top of the press or furnished for floor installation. Safety is provided by a counterbalance valve which prevents the platen from dropping through loss of pressure in the system, or because of excessive die weight.

Forty-eight models are available with either up-acting or down-acting platens, constant speed or variable speed pumping systems, and manual lever or electric push button controls for single or continuous cycling. **—K-41**

Butterfly Valves

B-I-F Industries, Inc., announces expansion of its line to include a full size range of 125-lb butterfly valves.

The expanded line is said by the company to be ideal as replacement valves, for pressure reducing and throttling functions, for street shutoff, pump discharge, altitude storage control, distribution systems.

The valves are designed for line sizes ranging from 4 to 48 in. They are lightweight and can be supported by the line. All meet and surpass American Water Works Association specifications for butterfly valves. **—K-42**

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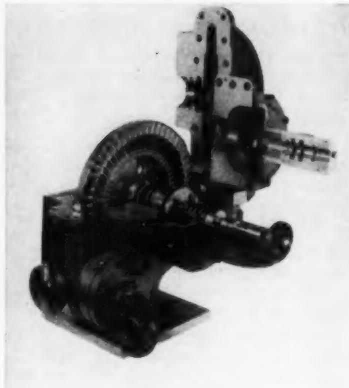
BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS



Gas-Expanding Turbine

Dean Hill Pump Co., Indianapolis, Ind., has announced production of a gas-expanding turbine, Type GET, which is said to be unique in small turbine design in that it is fully reversible.

The turbine can also be supplied with one row of blades for nonreversible operation. Applicable to gas pipeline valve operations, the unit is designed for 1 to 45 hp, with 1000 psig maximum inlet pressure. A mechanical speed governor, manual speed changes, and an overspeed trip valve are standard.

A forged, one-piece, two-row blade permits reverse rotation when gas or steam is directed against one or the other row of blades. Two hand-formed nozzles assure proper gas or steam expansion, and are located to activate either row of blades. A safety overspeed trip valve is actuated at a predetermined speed of 12,000 rpm.

—K-43

Miniature Siren

Electro Products Div., Western Gear Corp., announces the design and manufacture of a miniaturized siren suitable for missile application or other installations requiring miniaturized warning devices.

Less than 2 in. in diam the unit produces a tone of 1100 cycles per sec at 80 decibles at 11,000 rpm. It is powered by a 115 v a-c 400 cycle motor. **—K-44**

Pipe Repair Clamp

Marman Div., Aeroquip Corp., has introduced an improved heavy duty Patchmaster pipe repair clamp, manufactured for pipe sizes from 1/2 through 8 in. and in widths of 3, 6, 9 and 12 in.

According to the company, a new lug design allows the pipe repair clamp to conform to the contour of the pipe under high torque without biting into the pipe. It has a Buna N pad to withstand high clamping pressures without extruding, and is adaptable to oil, gas, water and steam. **—K-45**

KEEP INFORMED

BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Centrifugal Blower

A new compact, low-cost American Blower centrifugal air moving unit for electronic equipment cooling is now available from American-Standard Industrial Div.

Designated air unit No. 89C21, the new blower is designed for commercial applications. It is said to be especially well suited for cooling electronic tubes, ventilating small electronic equipment cabinets and cooling hot spots. The company recommends the unit for applications where nominal ambient temperature conditions can be anticipated.

Blower parts are of die-formed steel. Standard finish is blue-gray baked enamel paint, although other special finishes can be furnished upon request. The unit can be supplied with flanged outlet and mounting stand if required.

The $^1/_{40}$-hp shaded pole electric motor is of the unit bearing type and does not require oiling. It operates at 3000 rpm using 115-v, single-phase, 60/50 cycle or 230-v, single phase, 60/50 cycle current. The complete blower assembly weighs 6 lb; overall dimensions are approximately 6 $\times$ 6 $\times$ $8^1/_2$-in.

The unit operating at rated speed delivers 106 cfm of air at zero static pressure and 20 cfm of air at 1.0-in. w.g. static pressure.

—K–46

Hydraulic Valves

Rivett, Inc. has introduced a new line of 3000 psi pressure controlled hydraulic valves for such functions in a hydraulic circuit as relief, sequence, unloading, reducing and counterbalance.

According to the company, the new valves, designated Series 8800, are unique in that they provide the ability to obtain from a single basic valve assembly any one of the above functions. Full pressure rating can be obtained in all units at the point of valve opening.

The firm reports that pressure drop is minimized by providing liberal spool diameters, large openings, sizable internal passages to reduce turbulence. The regulating lands of the spool are fluted to provide smoothness of opening and closing, and to minimize the hydraulic shock.

Machined from closed grained Meehanite castings of special hydraulic quality, the valve bodies in destruction tests demonstrate bursting pressures of not less than 4 times maximum rating. The valves meet all JIC requirements, and are available in pipe and sub-plate mountings; with and without check, and direct operated or pilot operated.

Three basic sizes are available and choice is determined by desired capacity; with flow rating at 15 ft per sec the small nominal rating is 9 gpm with $^1/_2$ in. maximum pipe size: the medium nominal rating is 27 gpm with 1 in. maximum pipe size: and the large nominal rating is 55 gpm with $1^1/_2$ in. maximum pipe size.

—K–47

KEEP INFORMED

BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Actuator Motor

Electro Products Div. Western Gear Corp. announces the design and manufacture of a 26 volt d-c $1^3/_4$ hp compound wound reversible motor designed for actuator service.

The motor, having a speed of 10,500 rpm, is equipped with a brake having static torque of 500 oz-in. The motor is designed to meet requirements of MIL-M-H609A. It measures 7-in. in length by 4-in. in diameter, and is identified as Model 49ECl. **—K–48**

Pneumatic Motor

A compact pneumatic motor that has a cylinder volume of only 26 cu in. yet provides 150 ft-lb of torque and a 7-in. stroke is announced by Powers Regulator Co.

Called the Type LC, the piston-type motor is 75 per cent smaller than the double diaphragm motor it replaces. It can be mounted in any position to control vortex dampers, inlet vanes of refrigeration compressors, and large dampers.

A power package containing a positioning relay and a reverse relay powers the motor. The relays amplify the air signal from the controlling instrument to provide the air volume necessary to move the piston and position the motor quickly.

The motor has a torque rating of 150 ft-lb based on a 20 psi air supply, a crank radius of 5 in. and 90 deg travel. It can gradually control 200 sq ft of damper area up to 1200 fpm velocity.

A $^1/_2$ psi response is provided at the standard range of 10 psi. By adjusting the positioning relay, the range spring can be set to as little as 3 psi and as much as 22 psi for the full travel of the shaft. Air connections are $^1/_8$-in. NPT. Effective area is 18 sq in. **—K–49**

Solenoid Valves

A new series of high-flow, three-way, solenoid valves for general industrial use are announced by Skinner Electric Valve Div., New Britain, Conn.

The valves, which have been designated L3 series valves, are designed to control such media as oil, air, water, vegetable and petroleum oils, inert gases, kerosene, and gasoline. They mount in any position directly to the line, and operate on a pressure differential of 5 to 150 psi.

The firm is introducing these valves in $^3/_8$, $^1/_2$ and $^3/_4$ in. full effective orifice sizes and is making them available normally open, normally closed and with directional control in standard and explosion-proof construction.

It also is offering them in a wide range of voltages and frequencies with many electrical options. **—K–50**

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BUSINESS NOTES
NEW EQUIPMENT
LATEST CATALOGS

Relay Devices

Twenty-five amp mechanically held a-c relays are now available up to 24 poles from Automatic Switch Co.

The firm says the increased number of poles permits wider utilization of the relays as primary relay devices controlling contactors, solenoid valves and similar equipment, or as branch circuit devices directly controlling electric ovens and furnaces, lights and other loads within their capacity. **—K-51**

Winding Compensator

B. S. Roy & Son Co. have announced the development of a strip winding compensator which accurately controls the winding of wire strip on a mandrel.

The firm says this new compact unit makes a far more consistent package and eliminates expensive air pressure guides or other types of winding guide controls. The manufacturer reports excellent results with strip materials of brass, phosphorous, bronze, nickel, silver and stainless steel. Tests are currently being conducted on aluminum and magnesium.

Strip ranging in widths from 3 to 25 in. and .010 to .070 in. thickness have been processed without damage to strip's edges or surfaces. On many occasions strip of .002 in. thickness has been processed with excellent results. The manufacturer also notes that the strip can be processed through the compensator at normal operating speeds. An oscillating guide prevents damage to strip edges during the winding operation. Power is furnished by a one horsepower motor mounted near the mandrel. Each compensator is furnished with rubber rolls, hardened guide bars (adjustable from 3 to 26 in.) hardened and ground drive shaft rotating in bronze bushings and a drive sheave. **—K-52**

Chemical Metering Pump

CC Pump Div., Clark-Cooper Co. announces an addition to its line of controlled capacity chemical metering pumps.

The new unit is a diaphragm pump designed for positive displacement metering of a wide range of corrosive and non-corrosive liquids. The firm says the pump will satisfy requirements of high accuracy, low flow metering with four flow ranges available up to the maximum of 2.5 gph. A hydraulically balanced Teflon diaphragm is designed to eliminate flexing fatigue and distortion of flow rate. The new pump operates against back pressures as high as 500 psi and wetted parts can be constructed of such materials as plastic, stainless steel, nickel.

Construction includes built-in overpressure relief valve. Operating mechanism is totally enclosed and completely submerged in oil. It is available in multi-head construction and for automatic proportioning from pneumatic or electric impulse signal. **—K-53**

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BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Two-Volume Pump

A two-volume pump, requiring only a single pressure setting for both unloading and maximum pressure, has been announced by Vickers Inc., Div. of Sperry Rand Corp.

The company says the new pump prevents excessive heat generation and wasted horsepower by automatically maintaining system pressure with a small volume pump while a fixed differential between the relief valve setting and the unloading valve allows return of large volume pump capacity to the reservoir at negligible pressure.

Unloading response of the new single-adjustment (Type 33) combination pump is three times faster than the previous two-adjustment models. Pressure recovery is claimed to be exceptional and should improve the hydraulic circuit of many machine designs, particularly those requiring long runs of tubing or flexible fluid conduit.

Pumps incorporating this new feature are recommended by the firm for 1000 psi at 1200 rpm in the small volume operation and up to 750 psi at 1200 rpm in the larger volume operation. Two pump groups are provided. One with eighteen combinations of the small pump cartridges with capacities, at operating pressure, of 4.0 to 21.4 gpm for large volume operation. **—K-54**

BUSINESS NOTES

Opens Factory Branch

Davis Engineering, manufacturer of Paracoil heat transfer equipment, has opened a direct factory branch office at 7256 West Touhy Ave., Chicago 48, Ill.

Moves Headquarters

Farrel-Birmingham Co., Inc., has moved the headquarters of industrial gear sales from the company's main office in Ansonia, Conn. to its gear manufacturing plant, 344 Vulcan St., Buffalo, N.Y.

Chiksan Buys Hamer

Purchase of the business and properties of Hamer Valves, Inc., Long Beach, Calif., by Chiksan Co., Brea, Calif., has been announced jointly by the Companies.

Hamer's major products are plug valves, gate valves, and line blind valves marketed principally in the petroleum and chemical process industries. Chiksan, a subsidiary of Food Machinery and Chemical Corp., is a manufacturer of swivel joints, tank car and tank truck loading equipment, and barge and tanker loading systems.

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BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

West Coast Office

Van Huffel Tube Corp., manufacturer of metal tubing and rolled steel sections, has established a west coast sales office to be known as Van Huffel Western Corp. The new office is located at 4757 E. Slauson Ave., Maywood, Calif.

LATEST CATALOGS

Adjustable-Speed Drives

A 12-page booklet published by Reliance Electric and Engineering Co. gives detailed performance and application data on its line of all-electric, adjustable-speed V*S Jr. drives.

Covering typical applications employing the drives from $^1/_8$ through 4 hp, the booklet is illustrated with photos and cartoon drawings. Condensed specifications, dimensions, and a gearmotor selection table are included. **—K-55**

Oil Diffusion Pumps

Literature on advance design non-fractionating oil diffusion pumps has been released by Kinney Mfg. Div. New York Air Brake Co.

This improved series includes 1, 3, 4, 6 and 10 in. models, all with high pumping speeds in the range of 10^{-3} to 10^{-6} mm Hg. All are water cooled, with the exception of two air cooled models in the 1-in. series. **—K-56**

Packaged Boilers

Orr & Sembower, Inc. offers a four-page bulletin describing Power-Pak packaged automatic boilers in the 15 to 25 hp range.

Designed for low-pressure steam or hot water heating, these units include integral oil, gas or combination firing equipment and a wide selection of control and safety features. Heating coils may be added for instantaneous or storage tank hot water service. **—K-57**

Square Bar Data

An eight-page folder issued by Titan Metal Mfg. Co. gives complete sizes, pounds per foot, and alloy specifications for brass, bronze and nickel-silver rectangular and square bars.

The firm says this is the first known table listing of pounds per foot for rectangles and squares available from a brass producer. Commercial alloys treated in the folder include free cutting brasses, architectural bronze, forging brass, Muntz metal, cartridge brass, Naval brasses, etc. **—K-58**

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Gearmotors

A 32-page bulletin on gearmotors has been issued by the Jones Machinery Div., Hewitt-Robins, Inc., 666 Glenbrook Rd., Stamford, Conn.

The bulletin contains technical information on horizontal and vertical mounted gearmotors with capacity up to 125 hp and a variety of output speeds ranging from 780 rpm to 1.2 rpm. Included in the booklet is a load characteristics table for applications in various industries and different types of equipment, and a selection table arranged according to AGMA classifications. **—K–59**

Corrosion Chart

Damascus Tube Co. offers a wall chart providing comparative corrosion resistance of zirconium, titanium, tantalum, Hastelloy C, and stainless 316 tubing to 43 commonly encountered reagents.

Materials are shown with ratings from excellent (less than 3 mils per year) to not recommended (over 50 mils per year), for various concentrations and temperatures. **—K–60**

Electric Hoists

A selection guide for heavy duty electric hoists ranging from 1/4 to 12-ton capacity is presented in a 34-page catalog available from American Engineering Co., Wheatsheaf Lane and Sepviva St., Philadelphia 37, Pa.

Factors covered by the guide include capacity of hoist, speed and height of lift, dimensions of beam, type of hoist suspension, controls, current supply, and operating conditions. The catalog also contains dimensional drawings and detailed specifications for the firm's line of Lo-Hed electric hoists available for use on jib cranes, gantry cranes, single and double girder bridge cranes, as well as special monorail track or standard I-beam. Stationary hoists, electric car pullers and cabs for trolley hoists are also described. **—K–61**

General Utility Ejectors

Ingersoll-Rand, 11 Broadway, New York 4, has issued a four-page flier which describes its Series M general utility ejectors.

The firm says the new line of ejectors can be used to handle either wet or dry mixtures as well as mixtures containing solid materials such as chaff or dust. Accidental entrainment of liquid will not damage the ejector. They are designed to operate with steam or motive gas at 75 to 200 psig, and are available in 1 1/2, 2, 3 and 4 in. suction sizes with a total of 16 different ejectors. **—K–62**

Silicon Power Rectifier

Publication of a data sheet on its new Style 20 silicon power rectifiers, designed for operation at current levels from 1 to 15 amp (single phase half wave average) is announced by Syntron Co.

The illustrated sheet presents complete description, data and specifications for new rectifiers, showing surge ratings of 90 amperes average for 6 cycles (.1 second) and 50 amperes average for 60 cycles (1.0 seconds). Temperature range is from −65 to +175 C. **—K–63**

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Electric Tachometers

Electro-Mechano Co., has issued a new bulletin which describes its line of electric tachometers. Included is data on the firm's new Model 31, a large round indicator. —K-64

Precision Products Handling

A six-page bulletin issued by National Vulcanized Fibre Co., 1059 Beech St., Wilmington 99, Del., includes six case studies, describing how Kennett receptacles improve material handling efficiency and reduce product damage in leading industries.

Photographs illustrate the properties of the receptacles. Utility trays, nesting-stacking trays, bin-front trays, mill boxes, tote boxes, fibre trucks, drop-sided trucks, reusable shipping containers and barrels are illustrated. —K-65

Nitriding Process

An engineering bulletin, published by A. F. Holden Co., describes a recently developed liquid pressure nitriding process, tested and passed by the firm's research laboratories.

Bulletin 204 reports the process as an economical method for producing an extremely hard case on nitrided steel parts to make them resistant to spalling and softening at high temperatures. Also included are graphs showing relationships of case depths and hardness versus time in the salt bath furnace and data for controlling decarburization in nitriding baths. —K-66

Heat Exchanger Tubes

Scovill Mfg. Co. has made available a condensed eight-page brochure outlining the principal features, technical information and composition and applicable specifications for all its heat exchanger tube alloys for use in the power, petrochemical, marine and related fields. —K-67

Liquid Level Controller

A new Versa-Tran unit designed to give low cost, high precision level control for any electrically conductive liquid with a resistance below 25,000 ohms is described in a four-page folder available from Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44. —K-68

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BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Double Row Bearings

Double row ball bearings, including open, shielded and snap ring types, are described in a bulletin, No. 111, released by Hoover Ball and Bearing Co., 5400 S State Rd., Ann Arbor, Mich.

Dimension and load specifications for both light and medium series are provided together with a discussion of other application considerations. Double row bearings are used in applications requiring heavy radial loads, moderate thrust, shaft rigidity, and limited housing area. **—K-69**

Vibron Electrometer

Milton Roy Co. has released an engineering data sheet, EIL 33/3, which describes the Vibron electrometer manufactured by Electronic Instruments, Ltd., England.

The firm says the instrument was designed to measure very small d-c voltages and currents derived from high impedance sources. Its heart is a vibrating capacitor that replaces the conventional input tubes of electrometer circuits. It was developed for nuclear physics work and is capable of measuring currents in the order of 10^{-12} to 10^{-16} amp. Zero drift does not exceed 100 μv in 12 hr. Input resistance is 10^{13} ohms and can be raised to 10^{16} ohms.

The electrometer is used with pH electrodes and amplifiers to obtain direct readings of 0.002 pH units. It is also coupled with ionization chambers and industrial transducers using nuclear radiation. **—K-70**

Performance Meter

A data sheet describing the firm's Pi-Meter, a direct-reading performance meter for diesel, gasoline, natural gas, and steam engines is available from Korfund Co., Inc.

Bulletin K15A describes the construction and principle of operation of this indicator which reads time averaged pressure of engine cyclinders, thereby permitting rapid adjustment of engine for uniform cylinder performance. Pressure is read directly on the meter's dial in psi while the engine is running—no charts, graphs, or computations are needed. **—K-72**

Solenoid Valve

Engineering data sheet FR 108 describing its recently developed no-leak two way pilot operated solenoid valve has been made available by Fluid Regulators Corp.

The data sheet lists operating specifications, engineering data, and dimensional information. It also features a typical flow curve illustrating the very low pressure drop for this valve. The valve described is designed for use with hydraulic fluid MIL-0-5606 and similar liquids. Temperature range is −65 to +275 F for use in 3000 psi systems. The valve operates on 0.185 amp 25 volt d-c. **—K-73**

Hinged Closures

One-man hinged closures with built-in safety features for vacuum, low and high pressure service in petroleum, gas transmission, chemicals and other industries are described in a brochure available from Tube Turns Div., Chemetron Corp.

Photographs illustrate one-weld installation, maintenance and operation of the new product. Charts give dimensional specifications and cross-sectional drawings describe design features of various sizes and types. The closures are produced in sizes from 2 through 42 in. for ASA 150, 300 and 600 lb service, with larger sizes and other pressure classes available on special order. Counterbalanced, spring-loaded types are offered for vertical applications in sizes 18 through 36 in. for ASA 150 lb service. **—K-74**

Heavy Duty Counters

Heavy duty counters for indication, recording, and automatic regulation of material flow are described in a four-page bulletin issued by Richardson Scale Co.

Models designed for use with machinery all along the line of material flow, in receiving, process and inventory control, and shipping, are discussed. Also described are integrated ticket-printing components and impulsing switches, including an arrangement for housing switches in explosion-proof enclosures. **—K-75**

KEEP INFORMED

BUSINESS NOTES · NEW EQUIPMENT · LATEST CATALOGS

Air-Hydraulic Unit

Electro-Mechano Co. has announced a bulletin giving specifications on its new air-hydraulic unit made in sizes 2- and 3-in. bores, in 2-, 4-, 6- and 8-in. lengths.

The unit is designed for automation of milling machines, lathes, drill presses, packaging machinery, bottling machinery, assembly operations and circle sawing of wood. —K-76

High-Velocity Heaters

Door heaters to temper inrushing cold air when large outside doors are opened are described in a two-page bulletin available from L. J. Wing Mfg. Co.

Bulletin DH-59 describes high velocity door heaters for steam or hot water systems, to be mounted inside and above doors which must frequently be opened regardless of outside temperature. The heaters are designed to provide a curtain of heated air when doors open, to prevent chilling drafts and maintain even temperature within the building. —K-77

Torque Wrenches

P.A. Sturtevant Co., Addison, Ill., has available the second edition of a manual giving details on torque principles and the various types of equipment available for measuring torque.

A torque specification chart is included, along with data on attachments, formulas and computations, adapters, extensions and assembly characteristics. The 28-page booklet is illustrated with line drawings. —K-78

Rubber Parts

A six-page catalog describing various types of molded and extruded rubber parts for use on automobiles, aircraft, machinery, appliances, office equipment and railroad equipment is available from Garlock Packing Co.

The bulletin, designated AD-167, categorizes available rubbers in six groups and offers a detailed description of each type along with typical applications. In order to aid the user in choosing the right material for his specific application, the bulletin has a page of tabular material which shows the tensile strength, elongation, and compression for natural, SBR, nitrile, neoprene, Butyl and specialty fluoroelastomers Viton and Kel F. A second page of tabular material compares the physical properties and effect of environments on these types. —K-79

Packaged Boilers

A discussion of packaged firetube boilers—from construction features to final test and start-up service is highlighted in a 12-page brochure available from Cleaver-Brooks Co., Milwaukee, Wis.

The new bulletin covers package boilers through 600 hp for heating and processing, steam or hot water. It covers today's high standards in modern boilers, discussions of current design trends, burner design, automatic operation, efficiency ratings, and factory tests. —K-80

Subminiature Indicator

Waltham Precision Instrument Co., announces literature on its WT-1 subminiature elapsed time indicator.

The unit weighs under 3 oz and has a total readout of 10,000 hours, readable to the closest hour. Bulletin 5001 describes the physical and electrical characteristics of the unit and includes dimension drawings and an actual size template for panel layout. —K-81

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NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Equipment Control Connectors

A 12-page bulletin with information on new equipment control connectors has been published by Joy Mfg. Co., Electrical Products Div.

Constructed of neoprene, the new connectors are designed for applications up to 600 volts. They are available in three basic styles: oval, round or dual round—2 to 12 poles. The bulletin includes description of construction features, photographs of the products, dimensions, specifications and examples of typical applications. **—K-82**

Speed Reducers

Two new booklets containing detailed engineering data on Hewitt-Robins shaft-mounted, in-line helical and right-angle helical speed reducers are now available from the company.

Each booklet contains 24 pages of rating tables, selection procedures and other technical data useful to engineers specifying power transmission machinery. Booklet No. J-19 covers shaft-mounted reducers and No. J-18 deals with in-line and right-angle helical drives. **—K-83**

Direct-Drive Blowers

Dimensional and performance specifications on two series of direct-drive blower units with either center lock or standard double Airotor wheels are given in two new four-page technical bulletins published by the Air Impeller Div., Torrington Mfg. Co.

Performance curves give variations in static pressure, speed, power and current with air flow rate for the four blower models in each of two wheel diameter sizes. Different sets of test curves are given for the units running on a number of the most commonly used commercial blower motors. **—K-84**

Steel Heat Treatment

A 28-page technical booklet on modern principles of heat treatment of steel has been published by Uddeholm Company of America, Inc.

The booklet describes the derivation and meaning of the TTT diagram and provides fundamental information concerning various heat treating procedures including step-annealing, martempering and austempering. It also includes TTT diagrams for all commonly used grades of SAE tool steels and is illustrated with photomicrographs and charts. **—K-85**

Industrial Gloves

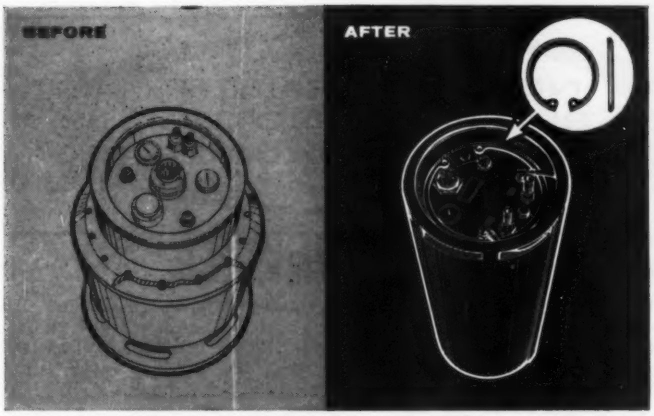
A 16-page catalog, illustrating its line of Wil-Gard industrial gloves and finger cots, has been published by Wilson Rubber Co., Div. of Becton, Dickinson and Co.

The gloves are available in disposable polyethylene, natural rubber, lined and unlined latex, lined and unlined black neoprene, unlined white neoprene, buna-n, and compar plastic. Finger cots, in various thickness, are made from latex or neoprene. Linemen's natural rubber gloves as well as leather protectors also are available. **—K-86**

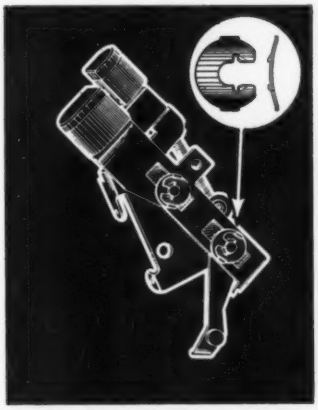
Compressed Air Data

Ingersoll-Rand Co. has published a booklet on compressed air fundamentals, designed to help in the selection of a small packaged air compressor for either automotive or industrial application.

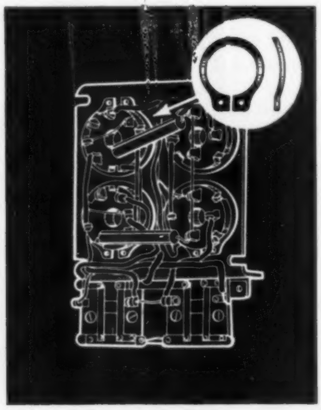
The booklet also basically describes compressed air, how it is compressed, single- and two-stage compressors, piston displacement, actual delivery, unloading of compressors, regulation and types of control used. Other material included is information on compressor oils, pipe sizes, wire sizes and terminology and definitions used in connection with the compression of air. **—K-87**



Pressure cover design simplified. Two axially assembled Truarc Series 5002 beveled rings eliminate 27 bolts, reduce machining and assembly time from 78 to 1½ hours and make possible drastic size and weight reductions. Rings retain two covers of a pressurized x-ray unit. **Savings: about $500 per unit.**



Parts eliminated in slide assembly. Two radially assembled Truarc Series 5139 Prong-Lock® Rings provide proper spring tension, eliminate looseness and wobble in this office calculator shift-slide. Original design called for a cut washer, spring washer, and cotter pin — all eliminated.



New way to install electron-tube sockets. Easy-to-apply Truarc Series 5101 bowed external rings lock tube sockets to chassis plate in this assembly. Bowed construction takes up tolerances of molded grooves, thickness of base. Individual sockets are removable for field service.

Quarter-turn clamp improved. A bowed washer and two locknuts were eliminated in this quarter-turn jig-and-fixture clamp by a Truarc Series 5131 bowed E-ring. The radially assembled ring holds the screw captive, provides required rotational drag between parts with sufficient tension to insure tight fit when the screw is first engaged. **Typical savings: $1.35/unit—assembly up 70%.**

Truarc rings for end-play take-up offer significant design advantages

A number of Truarc retaining rings are available to take up end-play or loose fit caused by accumulated tolerances and wear. The rings often eliminate spring washers, collars and set screws, nuts, bolts, rivets, cotter pins and other conventional fastening devices with outstanding cost savings in machining and assembly time.

Truarc retaining rings designed to deal with the end-play problem are of two general types: **bowed rings** for resilient end-play take-up and **beveled rings** for rigid end-play take-up.

Bowed retaining rings are widely used for preloading bearings, preventing vibration or oscillation in linkages, providing tension on adjusting screws. Of particular interest is the radially installed Truarc Prong-Lock® ring which locks securely to the shaft by means of two prongs. It provides exceptional thrust load capacity, may be used as a shoulder against rotating parts, and often eliminates springs, bowed washers and other tensioning devices.

In beveled rings for rigid end-play take-up, the groove-engaging edge is beveled at 15°. There is a corresponding bevel on the load-bearing groove wall. To take up end-play, the ring acts as a wedge between the outer groove wall and the part being retained.

These are just a few of the 50 functionally different types of Truarc retaining rings. They come in up to 97 standard sizes, six metal specifications, 13 different finishes. The entire line as well as accessory assembly tools, grooving tools, and over 70 typical applications are shown in the new catalog RR 10-58. Write for your copy today. And remember Waldes Truarc engineers are always ready to work with you on your specific projects. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N.Y.

 9.12.

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor, Inc., Long Island City 1, N.Y.

TRUARC RETAINING RINGS... THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

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NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Cast Aluminum

R. Lavin & Sons, Inc. has published a four-page brochure on its new high strength cast aluminum alloy called Hi Tensile.

The company says the alloy makes it possible to develop cast products with high strength and good ductility without expensive heat treating. Foundry qualities, mechanical properties, age hardening behavior, specifications and a list of its characteristics are included in the brochure. **—K–88**

Iron Valves

Walworth Co. has announced the publication of a new circular on standard iron body gate valves.

The new circular lists service ratings, sizes and dimensions, and material specifications for all the firm's iron body gate valves. A section devoted to higher strength cast iron wedge gate valves, used on many lines carrying steam, water, oil, and gas, is included. **—K–89**

Precision Boring

American Hollow Boring Co. has published a bulletin showing its facilities for producing precision borings and honed parts.

The 16-page brochure illustrates various equipment and operations in boring holes to specifications, precision testing, and outlines data on hollow bored cylinders with integral pads or weldments and external machining. **—K–90**

Automatic Boilers

A bulletin on the company's line of Powermaster Model 3 packaged automatic boilers has been released by Orr & Sembower, Inc.

The 12-page bulletin describes and illustrates boiler types, including gas, oil and combination gas-oil models, a new specially-designed hot water boiler, and the new steam atomizing principle for use with No. 6 oil. Ratings and dimensions of all sizes in the line are included, as well as details of burners, and cutaway drawings of boilers and burners. **—K–91**

Aircraft Components

Ketay Dept., Norden Div., United Aircraft Corp., has issued an illustrated 170-page catalog of synchros, servo motors, servo amplifiers, resolvers, rate gyros and potentiometers.

It contains specifications and outline drawings of 200 units. Included are details on synchros manufactured to MIL-S-20708A specifications. **—K–92**

Mortar, Castable Refractories

Two technical bulletins—one on chrome mortar, the other on chrome castable—have just been published by Refractories Div. H. K. Porter Co. Inc.

Bulletin 72 presents basic technical data on "Kromform," a dry, air setting chrome ore castable refractory. Bulletin 73 presents technical data on chrome base, air setting refractory bonding mortar, "Kromtite." Facts on how to select and properly use each of these refractory specialty products is classified under several headings. **—K–93**

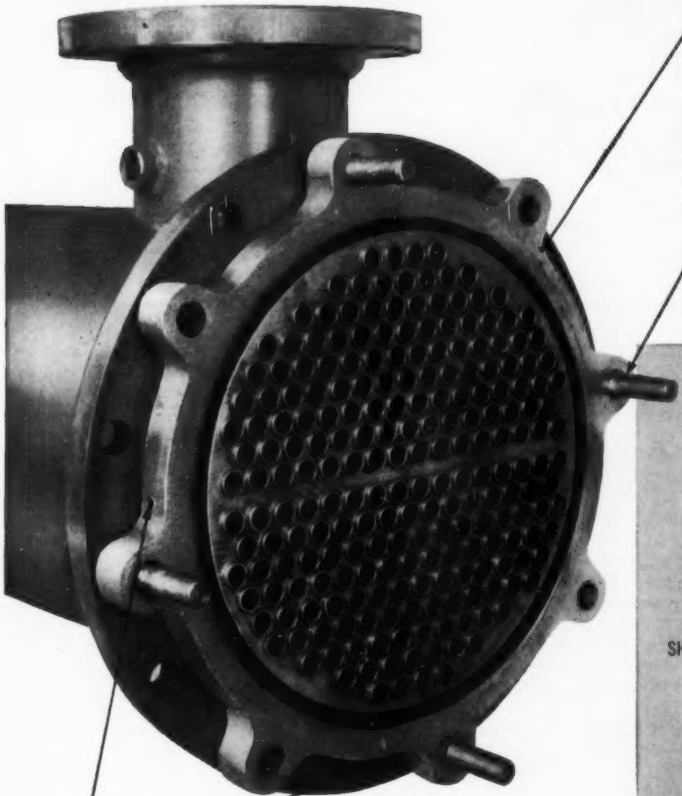
Simply remove the bonnet to make a shell side pressure test

Paracoil

EXCHANGER TYPE **PC**

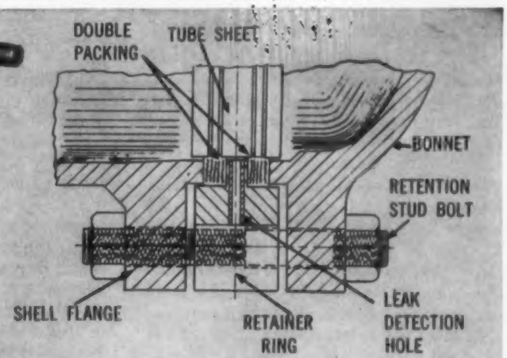
FOR ☐ COOLING ☐ HEATING

☐ OIL ☐ WATER ☐ AIR ☐ GAS



Unique retainer ring permits fast, easy inspection and servicing of packing. All that is necessary to set up a shell side pressure test is to remove the end bonnet by backing off on its single set of holding nuts. The retainer ring continues to hold the shell side packing in compression (see details below). No clamps or special devices needed. Piping connections are left undisturbed.

Retention stud bolts pass through the shell flange and screw into threaded retainer ring lugs, holding the ring and packing in place with bonnet off.



HOW IT WORKS

Section at packing retainer ring weephole. Seepage from either shell or tube sides drips out through copper-lined weephole. If tightening the gasket compression nuts fails to stop the leak, simply remove the end bonnet and pressure-test the shell side to locate the trouble—either the tube-end rolling or the shell-side packing. If neither, then the tube-side packing is at fault.

PARACOIL TYPE PC EXCHANGER

Leak detection holes at each 90° point in the retainer ring reveal any leakage past either the shell or tube side packing. **The absence of leakage indicates that the packing is holding—hence no dismantling is necessary for packing inspection.**

PARACOIL PC Exchanger tubes are straight for easy cleaning. The tube bundle is fully removable.

THESE DESIGN FEATURES SAVE HOURS OF MAINTENANCE TIME EVERY INSPECTION.

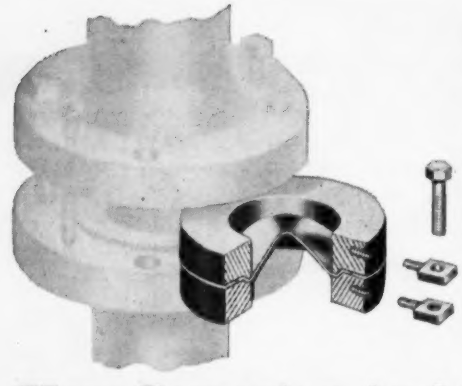
For details, write for Bulletin 140-A

DAVIS ENGINEERING

(A Division of American Metal Products Company)

520 Main Avenue, Wallington, N. J.


THERE MUST BE AN EASIER WAY
SUPPLYING BRANCHES AND SUBCONTRACTORS WITH BLUEPRINTS -IT'S EITHER A FAMINE OR A FEAST
WHAT'S THAT -WE DIDN'T SEND ENOUGH PRINTS FOR HALF YOUR MEN AT CAPE CANAVERAL?
LAST WEEK HE SENT 200 TO A GUY WHO NEEDED ONLY ONE
HOW DOES HE DECIDE-FLIP A COIN OR SPIN A ROULETTE WHEEL?
WE COULD THROW A BRAWL WITH THE AIR MAIL CHARGES ON THAT STACK MAZIE'S SENDING OUT
I KEEP TELLING HIM IF WE HAD A BLUEPRINTER MAKE AUTOPOSITIVE PAPER INTERMEDIATES WE'D ONLY HAVE TO SEND ONE OF THEM TO EVERYONE



New Life For Relief Valves

How Corrosion And Plugging Can Be Eliminated

Pressurized corrosives and coagulatives have always presented problems in the maintenance of relief valves. In one case deterioration of valve sealing surfaces is seemingly inevitable...in the other, valve aperture becomes restricted or completely clogged.

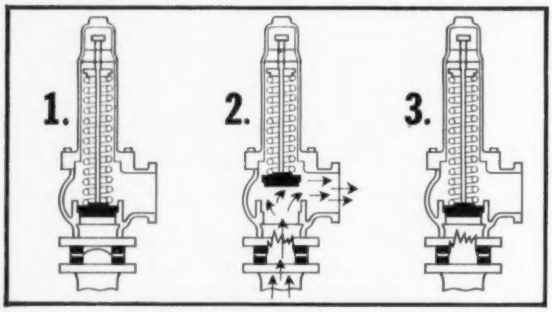
Positive Barrier Alone Won't Do The Job

The only sure way known to prevent these difficulties is to introduce a barrier between the pressurized product and the working parts of the relief valve. Of course just any sort of barrier isn't suitable. The effectiveness of valve operation would suffer. Therefore, the barrier must be removed at the precise moment that pressure reaches that point at which the valve must open.

This Special Barrier Does It

By installing a BS&B Quik-Sert Safety Head under the valve full protection of valve parts is provided. As long as normal operating pressure is maintained the rupture disc within the Safety Head remains intact... the valve is isolated from any unwanted influence present (Illustration #1).

When a predetermined pressure level is reached the barrier-disc ruptures instantly (Illustration #2). Pressure opens the valve, is bled back to normal, at which point the valve closes (Illustration #3). Processing or product transfer is continued temporarily without interruption.



Replacement Is Fast, Inexpensive

Later at any convenient time, when the system is idle, the valve can be cleaned and the Quik-Sert Safety Head replaced. A two-fold reduction in overall costs is achieved through the use of a Quik-Sert Safety Head for valve protection... (1.) Service life of the valve is multiplied, thereby saving the cost of replacement many times, (2.) Even in the event of abnormal overpressure, operations can continue without stoppage until normal completion is reached.

Change-Of-Operation Problems Reduced

Another advantage is provided by BS&B Quik-Sert Safety Head protection for relief valves. In the event unexpected changes are necessary in processing or there is a change in the character of the product involved, you will not need to change to a different safety or relief valve. The Quik-Sert previously in service can be removed and an alternate unit of the proper specifications installed beneath the same relief valve with a minimum of effort.

Valve Protection Not Only Use

Of course, the use of BS&B Safety Heads is not limited to application under relief and safety valves. Overpressure protection can be provided in any situation where ignition or exothermic reaction during a given process causes an abnormal pressure rise in seconds or milliseconds.

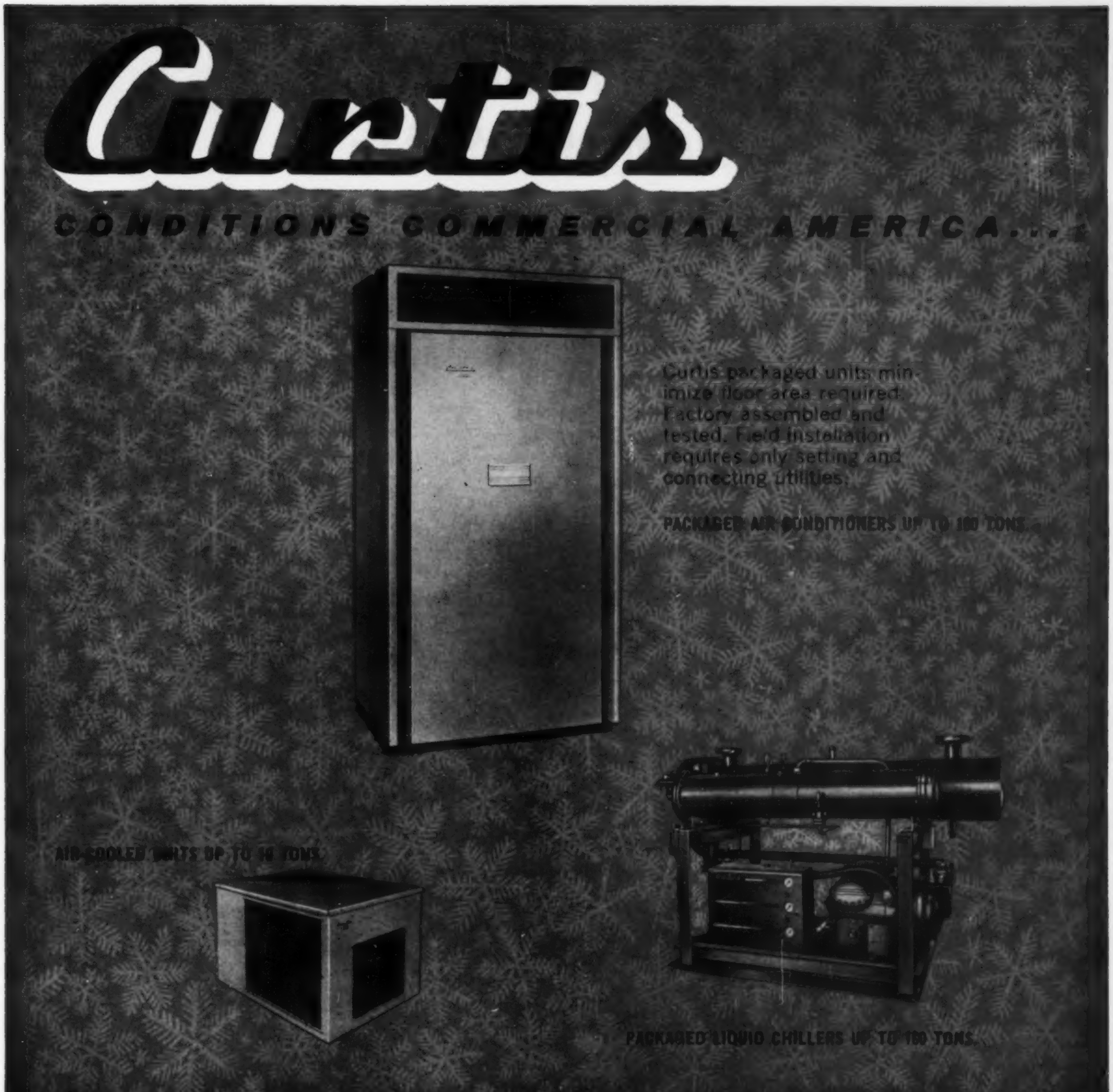
The uses and designs of Safety Heads are undergoing continuous expansion. Presently they are proving their value in such widely diversified fields as Food and Chemical Processing, Aircraft and Missile Propulsion, Oil and Gas Production and Processing, Air Conditioning and Refrigeration, Electrical Power Generation and many others.

Do You Have A Unique Pressure Problem?

New and unusual pressure relief requirements involving corrosives, elevated or sub-zero temperatures, pulsating pressures, alternate pressure and vacuum, pressure cycling, or even low-to-high-pressure shock are constantly being solved by the BS&B Safety Head.

If you need a device for the protection of relief or safety valves... if you need overpressure protection not requiring the use of valves or have a pressure transfer requirement calling for a device that will provide instantaneous pressure release, be sure to consider the BS&B Safety Head. It may very well be your answer. Contact your nearest BS&B Sales office or agent, or the Safety Head Division Headquarters in Kansas City.

BLACK, SIVALLS & BRYSON, INC., *Safety Head Division, Dept. 2-FQ 10*
7500 E. 12th Street, Kansas City 26, Missouri



PRECISION

close tolerance manufacturing, builds peak performance into every CURTIS unit.

Curtis is the "luxury line" in the air-conditioning industry. Silence, efficiency and long-life are inherent in Curtis design.

Yet Curtis prices are right in line.

This is why Curtis designs and builds thousands of unique air conditioning systems for commercial America . . . why Curtis is able to maintain a family of over 300 representatives and servicing contractors across the nation.

Put the advantages of CURTIS PRECISION into your next job.

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MANUFACTURING COMPANY
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OUR 105th YEAR

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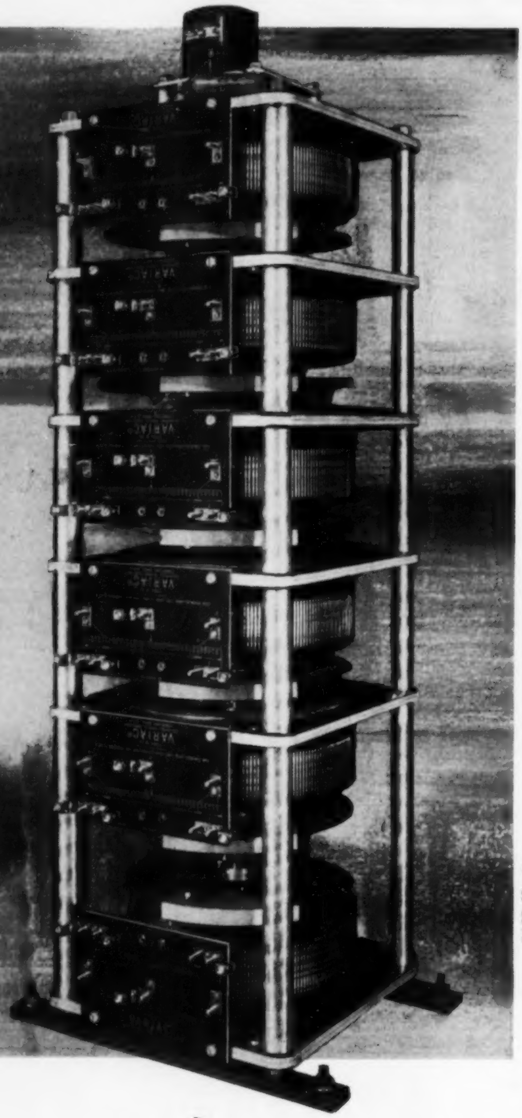
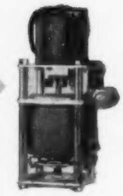
THE CURTIS "LUXURY LINE" OF AIR CONDITIONERS COSTS NO MORE

MOTOR DRIVES
For BIG Variacs...



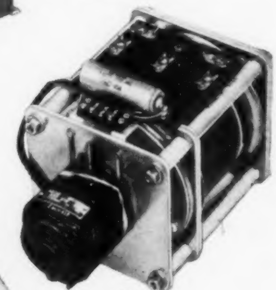
...and little Variacs



Type W2
2.4-amp . . .36 KVA

...and all sizes in between

Two-Gang W5 cased model . . .
5-amp per Variac . . .
1.8 KVA total



Type W10
10-amp . . . 1.5 KVA

Six-Gang W50
50-amp per Variac
34.5 KVA total

Three-Gang W20 . . .
20-amp per Variac . . .
9 KVA total

All Variac® auto transformers, single units and gangs, can be supplied with motor drive, either cased or uncased. Prices range from $99.50 for 2.4-amp Type W2 to $922 for six-gang 34.5-kva Type W50. Quantity discounts available.

ALL MOTOR-DRIVEN MODELS

- ★ are driven by a two-phase, servo-type gear-reduction motor, which may be operated from a 115v, 50-60-cycle line (necessary capacitor provided), or a servo amplifier.
- ★ can be supplied with electrical limit switches.
- ★ are equipped with ball bearings.

★ Traverse speeds of 2, 4, 8, 16, 32, 64, or 128 seconds are available in most models.

Write for complete information

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WEST CONCORD, MASSACHUSETTS

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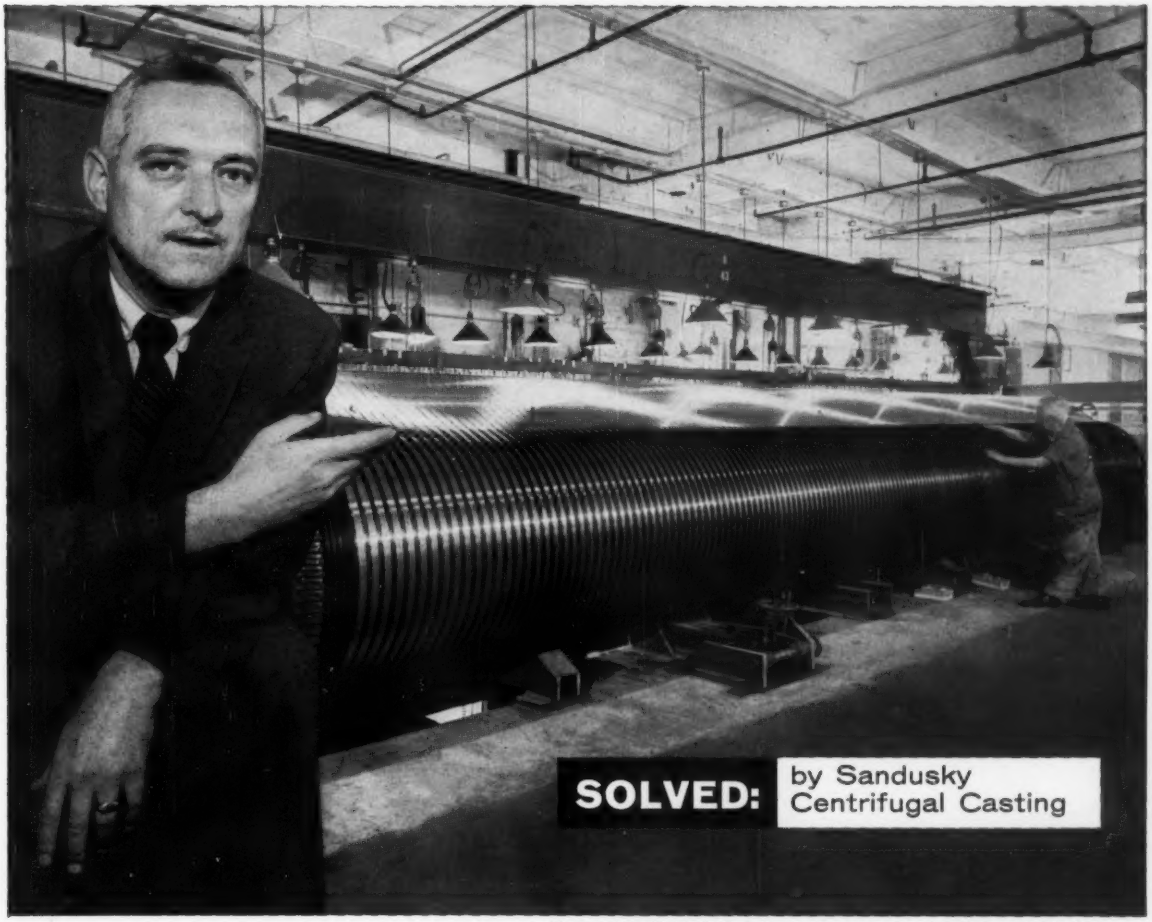


Eastwood-Nealley's chief engineer points out great size of grooved cylinder

Who else could cast this 22-ton cylinder for the world's biggest wire cloth loom?

To weave Fourdrinier wires up to 352" wide for the world's newest and largest paper machines, Eastwood-Nealley Corp., Belleville, New Jersey, required a cylinder over 30 feet long.

Sandusky supplied this 44,685 lb. roll, centrifugally cast of SAE-1030 steel and rough machined to 363" in length, 40⅛" on the O.D., to be used as the backbeam on Eastwood's new wire cloth loom. Since the cylinder had to be machined with 176 extremely smooth 2" x 2" stirs (grooves) in which wire is wound, it had to be of *flawless quality*. Otherwise any voids or inclusions exposed by machining would nick the delicate bronze strands and cause the expensive wire cloth to fail.

Eastwood-Nealley's chief engineer, Clemson A. Bower, asserts: "*We chose a Sandusky Centrifugal Casting because only Sandusky could make such a gigantic cylinder without welding. We were confident that our special machining operation would be accomplished without costly re-makes, for in the 12 years we have been using them, we never found a single flaw in a Sandusky Centrifugal Casting!*"

When cylinders or piping are needed in your design, keep Sandusky Centrifugal Castings in mind. We can supply cylindrical products from 7" to 54" O.D. and up to 33 feet long—made from a variety of alloys including stainless, carbon and low-alloy steels as well as copper- and nickel-base alloys. Send for free booklet, "Your Solution to Cylindrical Problems."

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

8804

SANDUSKY, OHIO Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

Materials are fed into top vibrating tier, drop down successively to bottom tier and leave through chute at lower left. System is enclosed to prevent heat loss and product contamination.

Jeffrey Vibrating Dryer

cuts pharmaceutical processing time 50%

By converting from batch processing of pharmaceuticals, Abbott Laboratories has cut processing time in half for grinding, drying and sizing a variety of drugs. In addition, uniformity and control of the product is improved.

A Jeffrey vibrating dryer is the heart of the system which reduces moisture from about 24% to less than ½ of 1%. The dryer is a three-tier design, to conserve space and eliminate the need for intermediate handling.

Materials are conveyed by low-frequency vibration in the Jeffrey dryer. Speed of travel and depth of material can be varied as required. Operation is automatic. Holding time in the dryer is only 12 minutes; average feed rate 300-400 pounds per hour.

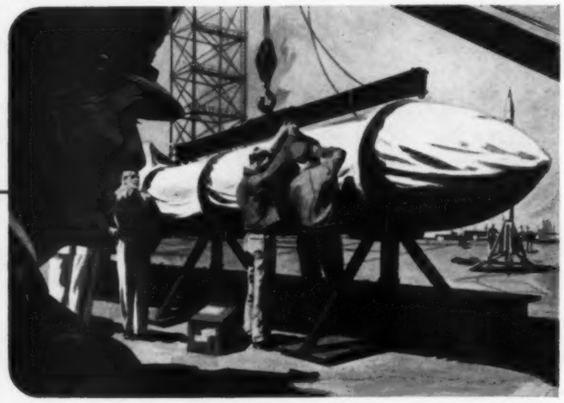
Jeffrey's broad experience in conveying and processing materials can help you cut processing costs. For information on Jeffrey products, write The Jeffrey Manufacturing Company, 915 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT... TRANSMISSION MACHINERY... CONTRACT MANUFACTURING

Pioneering Achievements in Missile Support Equipment at JPL

VEHICULAR EQUIPMENT . . . has been designed and developed having greater stamina and of much lighter weight. Specially designed prototype units were tested on rough terrain under the severest operating conditions. From these tests, significant design data resulted.



GROUND HANDLING EQUIPMENT . . . for servicing missiles and readying them for launching has been designed, developed and tested. However, a continuing program is in process at the Jet Propulsion Laboratory to further the state of the art in this important field.

MOBILE MISSILE SYSTEMS . . . were designed, developed and tested for use in transporting and servicing missiles. A tractor-trailer with launching pad in one complete unit was developed. Other equipment for loading and transporting missiles via air, land or sea has been developed.

GROUND SUPPORT EQUIPMENT . . . is developed to operate under conditions of rain, snow, ice, and heat. Mud and desert sand also create difficult environmental problems. Objectives are ease of operation and handling permitting the missile to be readily unloaded from airplanes, or landing craft and quickly positioned for firing.

jpl

CALIFORNIA INSTITUTE OF TECHNOLOGY

JET PROPULSION LABORATORY

A Research Facility operated for the National Aeronautics and Space Administration

PASADENA, CALIFORNIA

Employment opportunities for Engineers and Scientists interested in basic and applied research in these fields

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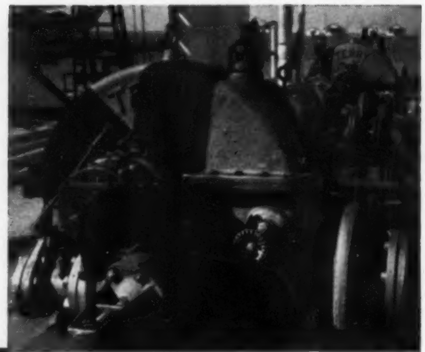
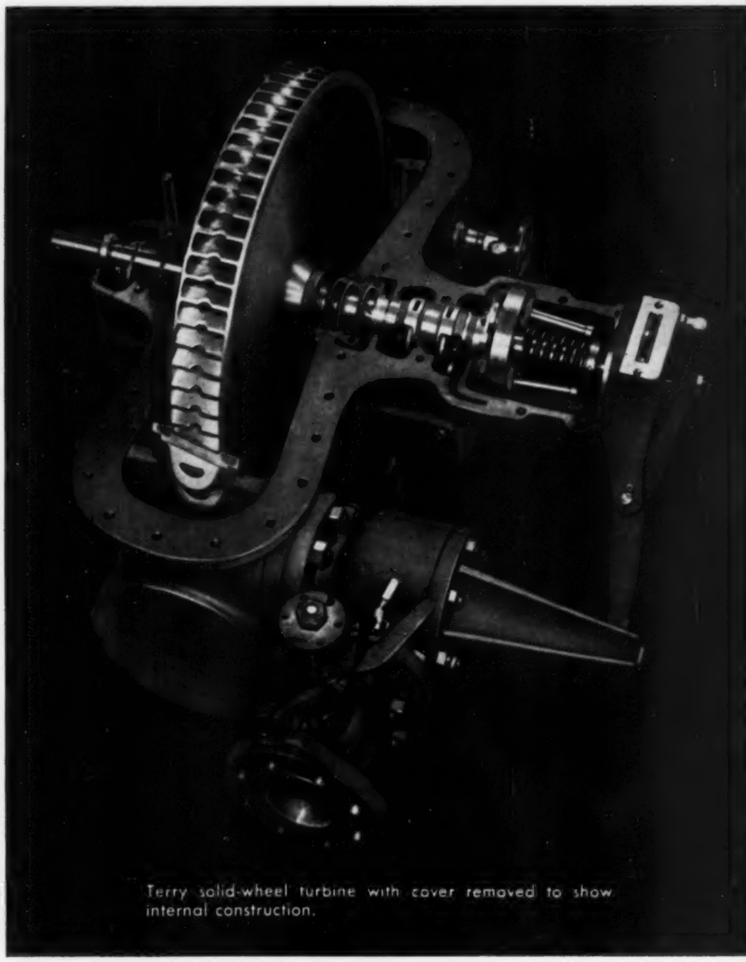


TERRY SOLID-WHEEL TURBINE

spells service continuity for mechanical drives



Terry solid-wheel turbine with cover removed to show internal construction.

For mechanical-drive applications, such as these, you will never find the equal of Terry solid-wheel turbines for built-in dependability. They are *designed* for trouble-free operation under the toughest service requirements.

The wheel, for example, is a single forging of special composition steel. Unlike a built-up wheel, there are no separate parts to loosen or work out. The blades can't foul since they are double-rim protected...with one-inch clearances at either side.

Any blade wear, which might occur after years of service, is of little consequence. As the power-producing action of the steam takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.

Specify Terry solid-wheel turbines for your next mechanical drives. They are available in capacities from 5 to 2,000 hp., speeds up to 10,000 rpm. Vertical turbines are built in sizes from 5 to 300 hp.

For full information about these reliable turbines, send for bulletin S-116.

THE TERRY STEAM TURBINE CO.
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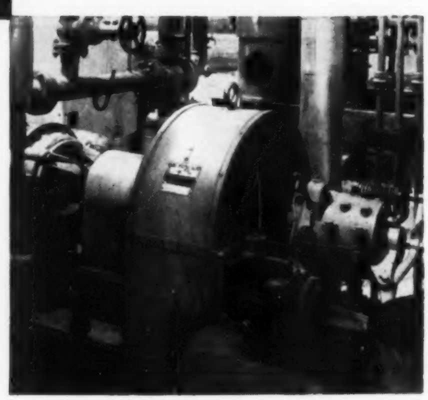

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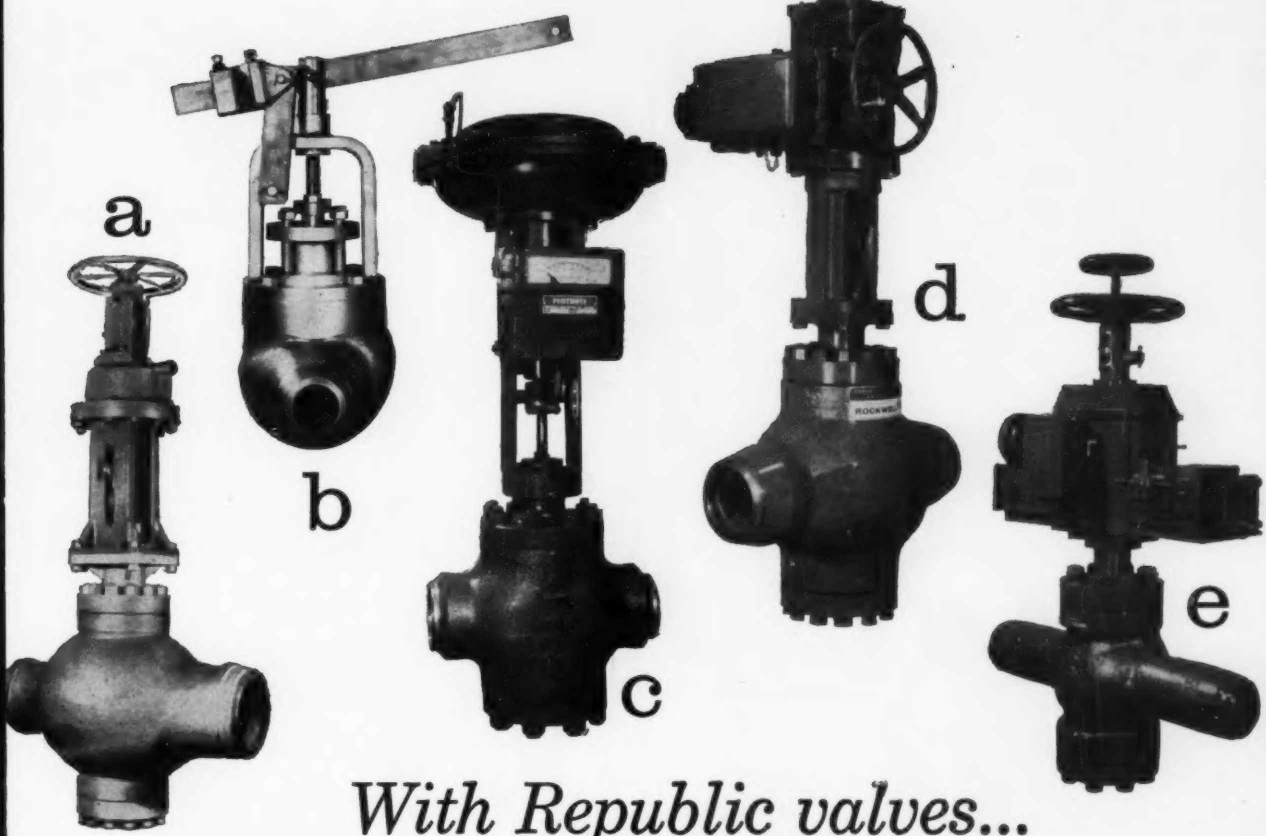

With Republic valves...

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For over 35 years Republic valve developments have paced the changing demands for more sturdy valves by the most progressive utilities and industries. For such services as pump recirculation control, feedwater regulation, steam pressure reducing and high pressure water control, Republic valves have established a reputation for durability, long life and trouble-free performance.

Superior valve design—Republic research into the causes of valve noise and vibration, and also the wear resisting and galling properties of materials has resulted in a modern line of Republic valves of advanced design. Republic valve contours are designed to produce not only the desired regulating characteristics but also to reduce erosion damage and noise as well. Extra large guide bushings, extra deep stuffing boxes, solid plug inner valve construction, plus precise manufacture and long-life materials make Republic regulating valves perform better, last longer, with less maintenance.

Wide selection of valves and features—Rockwell-built Republic regulating valves shown on this page are representative of the complete Republic line:

a. **Cylinder operated valve**
b. **Lever operated valve**
c. **Diaphragm operated valve**
d. **Motor operated valve**
e. **Toggle head operated valve**
f. **Diaphragm operated angle valve**

And, for many special applications, such Republic accessories as pneumatic and electric valve positioners for hysteresis-free control, and a complete line of controllers are available.

Whatever your regulating valve problem, let Republic engineers put their years of application experience to work for you. For additional information, see your Republic representative, or write to Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Illinois.

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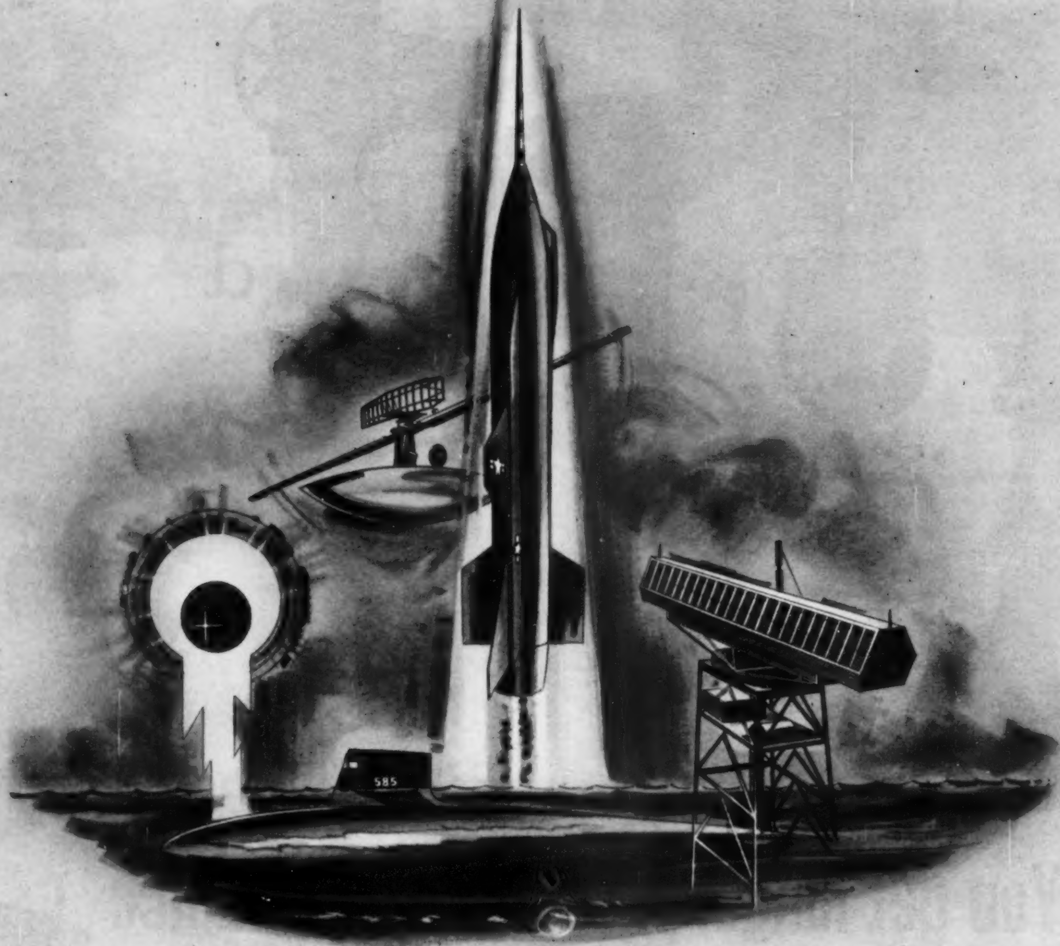

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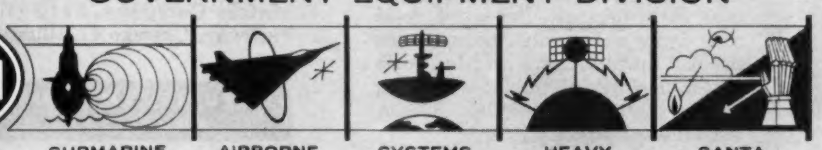

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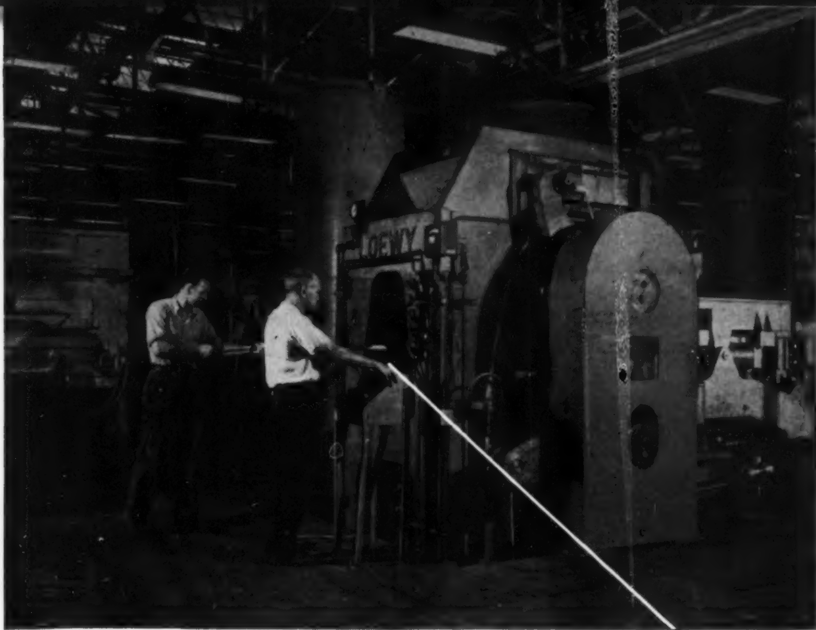


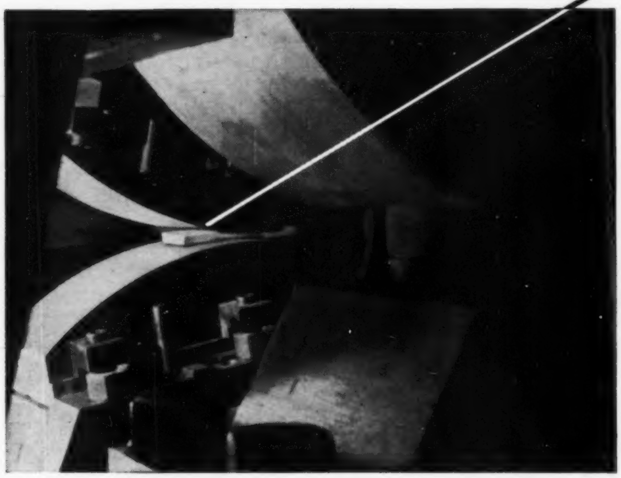
(Opposite)
Rectangular blade blank, withdrawn from electric furnace, is being inserted into automatic blade gripping and handling device.

(Below, Left)
Blade blank is pulled through and shaped by oscillating sector roll dies. Two dies, with their lips rolling on each other through arc of oscillating length, impress upon the blank the air foil shape required.

(Below, Right)
At end of rolling process, oscillating rolls open up and rotate back to starting position. Simultaneously the blade handling device returns the shaped blade and releases it pneumatically from grip head. Note spur gear synchronization of oscillating rolls, pressure selector switch, and 2-hand control pulpit.

Blade can be re-rolled for further reduction until final shape and tolerances are obtained, either after re-heat cycle or cold.

WORKPIECE (blade blank)



LOEWY ROLL-DIE forges air foil shapes with up to 40% reduction in one pass!

A 4-stand oscillating roll-die forging installation which shapes high-strength, high-temperature alloys by hot and/or cold reduction is in successful pilot operation at the Tapco plant of Thompson Ramo Wooldridge Inc., Cleveland, Ohio.

Thanks to this new Loewy machine, jet engine compressor and turbine blades up to 7 in. wide and 27 in. long can now be mass produced by plastic forming to close tolerances and with insignificant loss of critical material.

Unlike other machines, which use mechanical drives in rolling, it operates hydraulically. It is designed for both hot and cold forming under adjustable and pre-selected forming pressure up to 1200 tons. Forming pressure is applied lineally across the shape of the workpiece with great advantage over conventional die forging methods.

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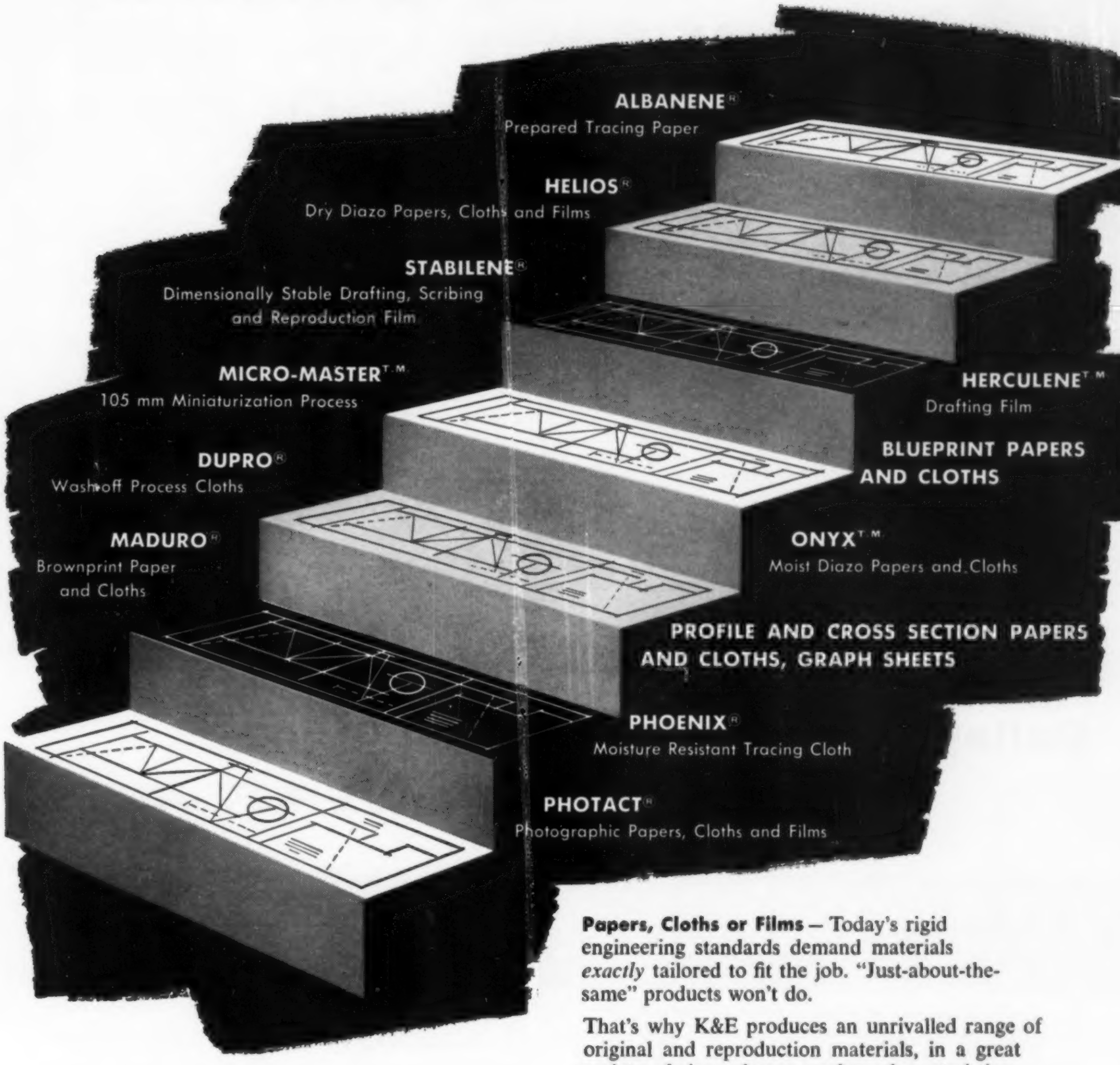

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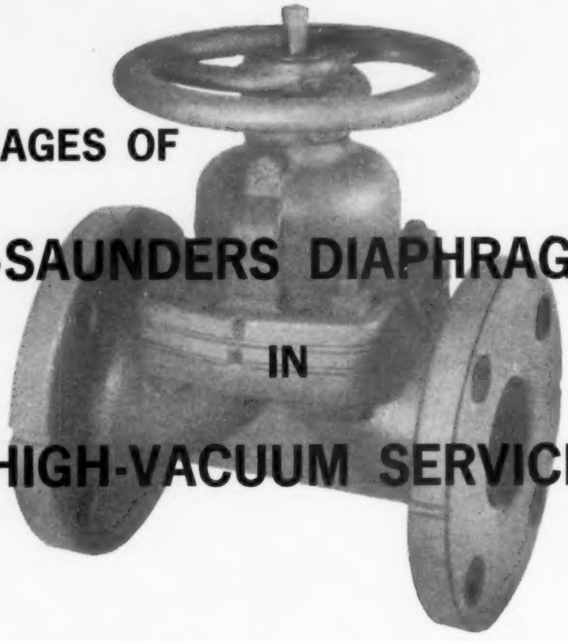
THE ADVANTAGES OF GRINNELL-SAUNDERS DIAPHRAGM VALVES IN HIGH-VACUUM SERVICE



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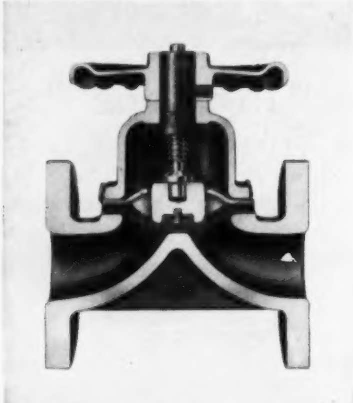
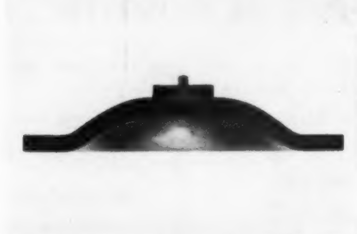
One of the most important requirements of valves for high-vacuum service is that they must be vacuum-tight at all times during their operating cycle. Diaphragm valves of the Grinnell-Saunders manufacture fully meet this requirement. When clamped between the flanges of the body and bonnet, the diaphragm is easily made vacuum-tight down to 0.1 micron — with an in-leakage rate of less than 0.1 micron cubic foot/hour. Whether in the open, throttling or closed position, the diaphragm presents a smooth, unbroken face to the vacuum side of the chamber.



Valve provides vacuum-tight seal in closed position

Rugged, nylon-reinforced diaphragms in a variety of materials

Grinnell has perfected a method of reinforcing its diaphragms with wear-resistant nylon. The result is a diaphragm that lasts longer at high-vacuum. The only part of the valve subject to service wear at any time is the diaphragm — which can easily be replaced in a matter of minutes, without removing the valve body from the system. Diaphragms are available in a wide choice of materials.



Rugged, reinforced nylon diaphragm gives long-lasting life

Contamination minimized

Construction of Grinnell-Saunders Diaphragm Valves provides separation of the working mechanism from the vacuum within the system. This isolation of lubricated working parts prevents contamination of the system from lubricant outgassing.

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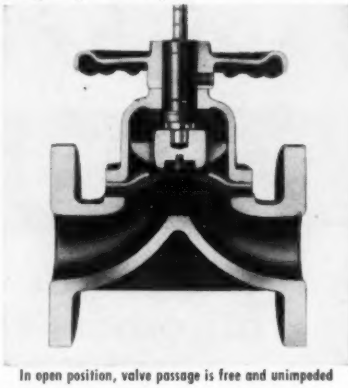
The large passage of the Grinnell valve, in the open position, offers minimum impedance to the escape of random moving molecules in pumping down to high-vacuum, thus shortening the pump-down cycle.



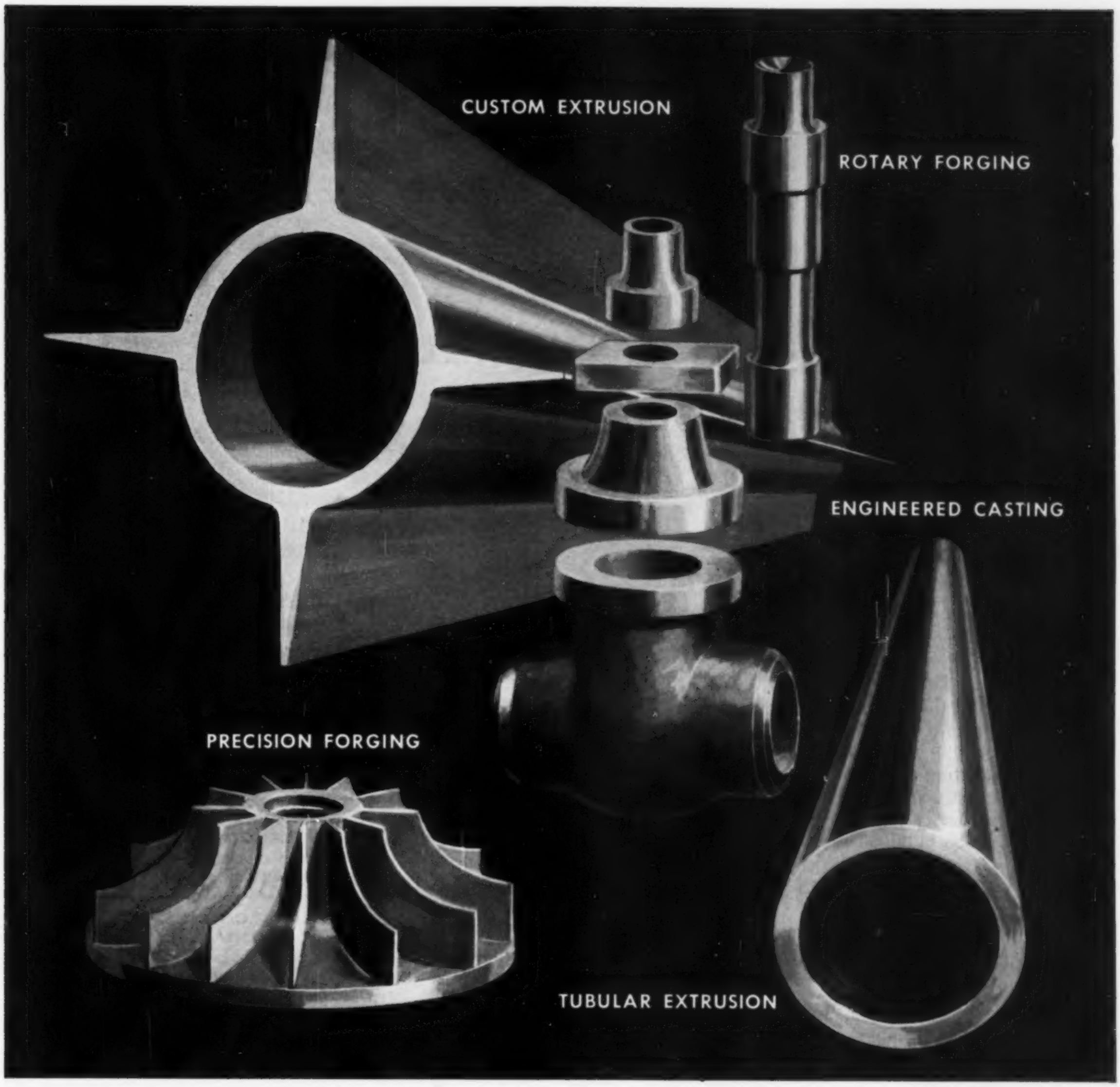
In open position, valve passage is free and unimpeded

Special provisions:

Sealed bonnets are available for evacuation when required. Elastomer type diaphragms do not require evacuation of the bonnet. Valves with plastic diaphragms, used at elevated temperatures, do require evacuation of the bonnet for long diaphragm service life.

For more information

Get further facts about Grinnell-Saunders Diaphragm Valves. Learn how the diaphragm lifts high for streamline flow in either direction . . . and how the diaphragm seals firmly against the body weir for leak-tight closure. Write to: — Grinnell Company, Providence 1, Rhode Island.



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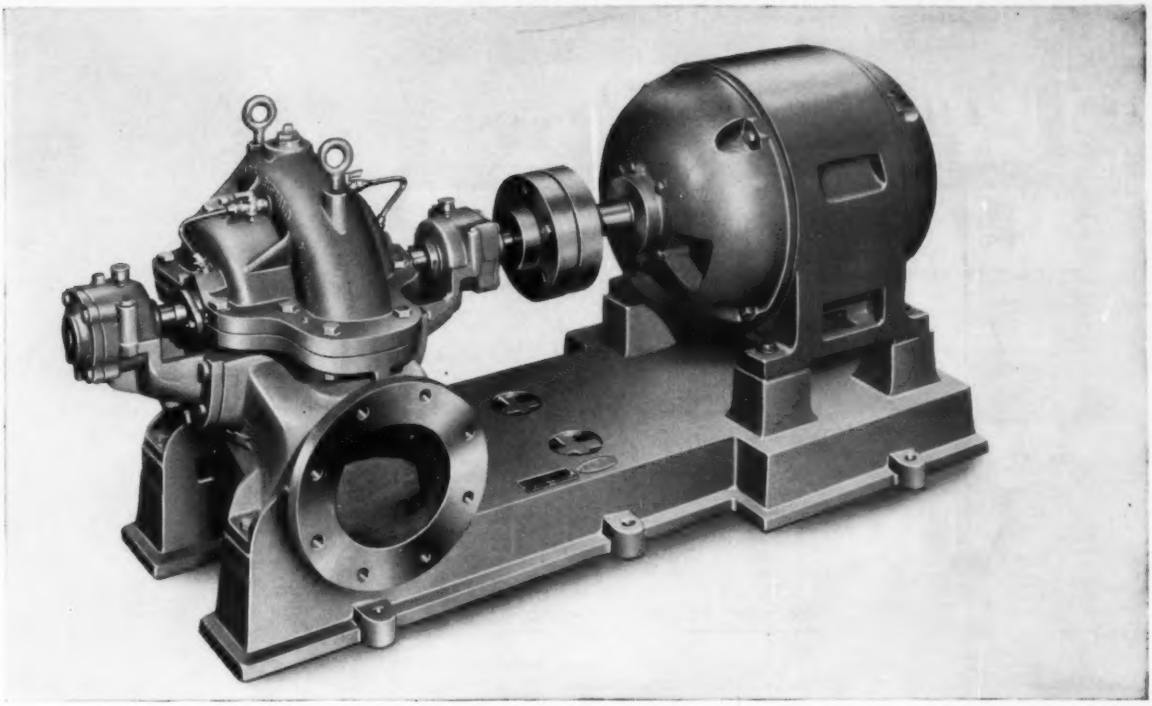

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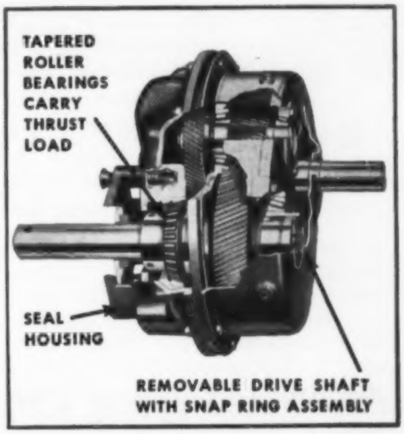

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Continued on Page 216

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Continued from Page 215

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MECHANICAL ENGINEERING
September, 1959 CARD INDEX Vol. 81, No. 9

Management Looks at Maintenance, Glenn B. Warren 46
Utilities Study Incremental Maintenance Costs, R. H. Holyoak .. 48
Central Job Shop In Area Maintenance, C. H. Harker 50
Regenerators for the "Whirlfire," P. T. Vickers 53
A Review of Metal-Processing Literature 57
Metal Cutting, J. M. Galimberti, R. S. Hahn, H. J. Siekmann, and E. G. Thomsen; Plastic Working, F. W. Boulger; Grinding, George Reichenbach
Editorial 45
Briefing the Record 64
Photo Briefs 72
European Survey 74
ASME Technical Digest 76
Comments on Papers 86
Reviews of Books 89
Books Received in Library 91
ASME Boiler and Pressure Vessel Code 93
The ASME News 96

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INDEX TO ADVERTISERS

ACF Industries (Inc.)
W-K-M Div. 177
Acme Chain Corp. 161
*Aerovent Fan Co. 205
*Air Preheater Corp. 203
*Allis-Chalmers Mfg. Co. 144
*American Pulverizer Co. 166
ASME Publications 146, 162, 192
Mechanical Catalog 200
Argonne National Laboratory 190
Armour Research Foundation 212
*Armstrong Machine Works 172
Army Engineer District, Omaha 207
Associated Spring Corp. 202

*B-L-H Loewy-Hydropress Div. 189
*Babcock & Wilcox Co.
Boiler Div. .... 2nd Cover
Tubular Products Div. 4
*Bailey Meter Co. 194
Barco Mfg. Co. 148
Battelle Memorial Institute 212
Bell Telephone Laboratories 217
Black, Sivalls & Bryson 174
*Blaw-Knox Co.
Copes-Vulcan Div. 24
Power Piping Div. 206
*Boston Gear Works 20
*Buffalo Forge Co. 8
*Buffalo Pumps
Div. Buffalo Forge Co. 199
Bundy Tubing Co. 25
*Bunting Brass & Bronze Co. 145

Caterpillar Tractor Co. 198
Celanese Fibers Co.
Div. of Celanese Corp. of America .. 207
Chace, W. M., Co. 149
Chrysler Corp.
Engineering Div. 212
Clarage Fan Co. 195
*Columbia-Geneva Steel Div. 12–15
*Combustion Engineering (Inc.) 2
*Crane Co. 34
Curtis Mfg. Co.
Refrigeration Div. 175
*Curtiss-Wright Corp. 197

Davis Engineering
Div. American Metal Products Co. 171
DeZurik Corp. 204
*Diamond Power Specialty Corp. 26, 27
Dresser Industries (Inc.)
Pacific Pumps (Inc.) 220
Roots Connersville Blower Div. 17
Dudek & Bock Spring Mfg. Co. 170
du Pont, E. I., de Nemours & Co. 21

Eastman Kodak Co. 173
Edward Valves (Inc.)
Sub. Rockwell Mfg. Co. 38, 39
Ellison Draft Gage Co. 204
*Erie City Iron Works 30, 31
27th Exposition of Chemical Industries 152

Faber, Eberhard, Pencil Co. 168
*Fairbanks, Morse & Co.
Diesel Div. 157
Pump Div. 150
*Falk Corp. 201
*Flexonics Corp. 40

*Foster Wheeler Corp. 22, 23
Foxboro Co. 9
Frick Co. 153

General Electric Co. 210
General Radio Co. 176
General Telephone Laboratories 215
*Grinnell Co. 196

Hamilton, Alexander, Institute 11
Hamilton Mfg. Co. 33
Hamilton Standard
Div. United Aircraft Corp. 213, 214
Homestead Valve Mfg. Co. 37

International Business Machines ... 208, 209

Jeffrey Mfg. Co. 180
Jenkins Bros. 140
Jet Propulsion Lab.
Div. Calif. Institute of Tech. 182
Johnson, Carlyle, Machine Co. 36

Kellogg, M. W., Co. 29
Keuffel & Esser Co. 193
Koppers Co.
Fast's Coupling Dept. 16

Little, Arthur D. (Inc.) 210
*Loewy-Hydropress Div., B-L-H 189
Los Alamos Scientific Lab. 213
Lukens Steel Co. 32

McDonnell & Miller (Inc.) 154

*Marsh Instrument Co.
Div. Colorado Oil & Gas Corp. 191
Mead Corp. 209
Merriman Bros.
Lubrite Div. 167

Nagle Pumps (Inc.) 158
National Distillers & Chemical Corp. .. 214
New Departure Div.
General Motors Corp. 1
*New York Blower Co. 165

Ohio Gear Co. 160
Ozalid Div.
General Aniline & Film Corp. .. 3rd Cover

Pacific Pumps (Inc.)
A Div. of Dresser Industries 220
*Pangborn Corp. 151
*Peerless Pump Div.
Food Machinery & Chemical Corp. 183
Powell, William, Co. 10

Raybestos-Manhattan (Inc.)
Manhattan Rubber Div. 28
Packing Div. 142, 143
Raytheon Co. 188
Republic Flow Meters Co.
Sub. Rockwell Mfg. Co. 187
Rocketdyne Div.
North American Aviation (Inc.) .. 163
Rockford Clutch Div.
Borg-Warner 159
Roots-Connersville Blower Div.
Dresser Industries (Inc.) 17
Rust-Oleum Corp. 18, 19

*Sandusky Foundry & Machine Co. 179
Screw & Bolt Corp. of America 162
Smoley, C. K. & Sons (Inc.) 167
*Southwest Products Co. 205
Southwest Research Institute 212
Spraying Systems Co. 170
Standard Oil Co. of Ohio 210
*Syntron Co. 219

*Tennessee Coal & Iron Div. 12–15
*Terry Steam Turbine Co. 186
Texas Instruments (Inc.) 211
Thomas Flexible Coupling Co. 163
Timken Roller Bearing Co. .... 4th Cover
Traders Research (Inc.) 204

U. S. Borax & Chemical Corp. 207
*United States Steel Corp. 12–15
*United States Steel Export Co. 12–15

*Vogt, Henry, Machine Co. 184
*Voss, J. H. H., Co. 205

W-K-M Div. of ACF Industries (Inc.) 177
Waldes Kohinoor (Inc.) 169
Whiton Machine Co. 164
Winsmith (Inc.) 147
*Worthington Corp. 181

*Yarnall-Waring Co. 139
Yoder Co. 185
*Yuba Consolidated Industries (Inc.) .. 6, 7

*Zallea Bros. 35

* **The asterisk indicates that firm has product catalog in the 1960 Mechanical Catalog.**

Your attention is directed to

Keep Informed Section 141–170
Consulting Service 216
Opportunities 207–216
Engrg. Soc. Personnel Service .. 135
(Agency)

Advertisers appearing in previous 1959 issues

Addison-Wesley Publishing Co.
All American Tool & Mfg. Co.
Allen-Bradley Co.
American Cast Iron Pipe Co.
American Hollow Boring Co.
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*James, D. O., Gear Mfg. Co.
Jordan Corp.
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United States Graphite Co.
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  Div. Sperry Rand Corp.

Western Gear Corp.
*Westinghouse Electric Corp.
  Sturtevant Div.
*Wheeler, C. H., Mfg. Co.
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